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THE
ASIATIC SOCIETY OF BOMBAY
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TO

DR. BLACK.

THIS tranſlation of *Fourcroy's Elements of Chemiſtry*, a work which has been honoured with his recommendation of it to the ſtudents of Chemiſtry, is reſpectfully dedicated, by

His obedient,

And very humble Servant,

THE TRANSLATOR.

EDINBURGH,
Mar. 4. 1796.

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ADVERTISEMENT.

THE general truths in any ſcience are continually multiplied, as its perfection advances, and as its means of inveſtigation are improved. Such has been the fortune of chemiſtry. Its firſt principles have been but lately aſcertained: And it is already rich in corollaries, or general reſults, which embrace and combine all its parts. A ſyſtematic view of theſe reſults may be highly uſeful. During theſe laſt twelve years, I have conſtantly endeavoured to arrange them into ſome ſuch form. I have often, in my courſes of lectures, given a ſketch of the arrangement I had adopted: More particularly, in thoſe lectures, with which I every year cloſe my courſe. When explaining the phænomena exhibited by the known elaſtic fluids in their evolution, their fixation, and their influence upon all the operations of Art and Nature; I take occaſion to review the fundamental principles of the Science; and give ſuch an abſtract of its whole materials, as recalls to memory all the changes to which natural bodies are liable, under the power of their reciprocal attractions. But, in any attempt to combine together theſe capital truths, great perſpicacity of diſcernment is requiſite, to enable us to ſelect thoſe more general facts, in which all the minuter ones are be ſo comprehended, that they may be deduced from them, as ſo many corollaries. Thoſe more general facts muſt likewiſe be expreſſed with perſpicuity and preciſion, without ambiguity, without doubt, without looſeneſs of language. They muſt not be too numerous, but yet ſufficiently ſo to include every general fact of any importance. They muſt alſo be arranged in ſuch a conſecutive ſeries, and with a mutual connexion ſo natural; that they may exhibit all the elements of the ſcience, and may ſhew their reciprocal relations and dependencies.

Theſe ideas have regulated my inveſtigation of thoſe truths. I thought that they might ſerve for the foundations of a complete ſyſtem of chemiſtry; which ſhould embrace ſuch a number of principles, and thoſe ſo happily applicable to every minuter phænomenon; that it might enable perſons already well acquainted with the ſcience, to recollect all that immenſe multitude of facts of which it is compoſed; and might, at the ſame time, explain to the beginner in chemical ſtudies, the nature of the courſe on which he is entering.

It appeared to me, that I ſhould beſt accompliſh this purpoſe, by exhibiting a regular ſeries of propoſitions, allied to one another by general relations, and ſo arranged, that their mutual connexion might be eaſily perceived. This I call *The* PHILOSOPHY OF CHEMISTRY. All the propoſitions contained in it, have been already printed under the article AXIOMS, in the chemical department of the New Encyclopædia. For the uſe of the ſtudent of chemiſtry, I have thought proper to publiſh them alſo apart, and in a commodious form.

The ſucceſs of the firſt edition of *The* PHILOSOPHY OF CHEMISTRY, has encouraged me to reprint it. I have made a few alterations, and ſome ſmall corrections, but hardly any addition. The nature of the work is ſuch, that it can be little enlarged, until the ſcience ſhall be greatly augmented, and enriched with important new diſcoveries.

PHILOSOPHY

PHILOSOPHY OF CHEMISTRY.

ALL the obſervations and experiments of Chemiſtry, may be reduced under the twelve following general heads.

I. The action of *Light.*

II. The action of *Caloric.*

III. The action of *air in Combuſtion.*

IV. The nature and action of *Water.*

V. The nature and action of *Earths;* the formation of *Alkalis;* and the parts which theſe bodies act in *combinations.*

VI. The nature and properties of *Combuſtible Bodies.*

VII. The formation and decompoſition of *Acids.*

VIII. The union of *Acids* with *Earths* and *Alkalis.*

IX. The oxidation and ſolution of *Metals.*

X. The nature and formation of *Vegetable Subſtances.*

XI. The tranſition of *Vegetables* into the ſtate of *Animal Matters;* and the nature of *Animal Matters.*

XII. Laſtly, the ſpontaneous *decompoſition of Vegetable and Animal Subſtances.*

THESE twelve articles may be made the titles of ſo many chapters; under each of which, may be introduced all ſuch particulars as have a more natural and direct connexion with it, than with any of the others; and which ſhall all together comprehend the whole ſum of our Chemical Knowledge.

CHAPTER I.

The ACTION *of* LIGHT.

I. LIGHT, whether it be emitted from the Sun and the Fixed Stars, or be naturally diffuſed through all material ſpace, has four different modes of action in reſpect to the other bodies with which it comes into contact. It is either reflected wholly without decompoſition from their ſurfaces, ſo as to give the ſenſation of *Whiteneſs*, when it meets the eye: Or it is decompoſed, and but partially reflected, exhibiting any of all the variety of colours, except *White* and *Black*: Or it is more or leſs entirely abſorbed, ſo as to afford to the eye, nothing but a *Black* ſhade: Or it paſſes through the bodies meeting it, with a greater or a ſmaller deviation from its former direction towards the perpendicular; which conſtitutes *Tranſparency*.

II. Paſſing through tranſparent bodies, it is refracted in the direct ratio of their denſity, if they be incombuſtible; and the refraction increaſes in the direct ratio of the increaſe of the combuſtibility of the body through which the light paſſes. Hence did Newton conjecture the combuſtibility of the diamond, and the exiſtence of a combuſtible principle in water.

III. Light ſuffering refraction, is decompoſed into ſeven different rays; red, orange, yellow, green, blue, indigo, and violet. It has been ſuppoſed, that three of theſe colours are ſimple; red, yellow, and blue; but the other four, compounded, each of thoſe two which appear on each ſide, next to it in the refracted pencil of rays; orange, of red and yellow; green, of yellow and blue; indigo, of blue and violet; violet, of red and indigo. This opinion, however, has not been ſatis-

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ſactorily proved. The decompoſition of light by the priſm, is a ſort of analyſis of it.

IV. Light acts likewiſe *chemically* upon bodies, in proceſſes of combination and decompoſition. Bodies immerſed in light, differ in their character, from bodies kept remote from its contact; even when the other circumſtances are equal. The former uſually become coloured, volatile, and inflammable; the latter exhibit properties oppoſite to theſe.

V. By this chemical action of light, ſome acids are decompoſed, and various other ſalts undergo a change of nature; metallic oxides are in general reduced nearly to the metallic ſtate; vegetables acquire colour, ſapidity, and inflammability. Plants withdrawn from the impulſe of light, remain white and inſipid; in conſequence of which they are ſaid to be *ætiolated.*

VI. Light ſeems to produce theſe effects, almoſt ſolely by abſtracting from bodies which have been burnt, that principle which they abſorbed during the combuſtion; and by thus reſtoring to them that combuſtibility which they had loſt. It may be ſaid, that light *unburns* burnt bodies.

The *foregoing propoſitions* may be *applied* to explain

The colours of bodies;
Tranſparency;
Opacity;
Brilliancy;
Single or double refraction;
Metallic luſtre;
The decompoſition of acids and of metallic oxides;
Decompoſition;
The alteration of mineral colours;
Vegetation;
The renovation of the vital air in the atmoſphere;
The decompoſition of water by the leaves of plants;
The formation of oils;
The differences of nature, which diſtinguiſh the vegetables of hot, from thoſe of cold climates.

CHAP. II.

The ACTION *of* CALORIC.

I. THAT which mankind in general call *Heat*, is *a ſenſation* produced by a ſubſtance which modern chemiſts denominate *Caloric*. Caloric applied to the human body, in a proportion larger than that in which it already exiſts in it, warms our frame, and preſents heat to our ſenſes. When matters lower in temperature than our body, are applied to it, there is a portion of its caloric abſtracted; and we feel, of conſequence, the ſenſation of cold.

II. Caloric penetrates through all the other ſubſtances in nature. It ſeparates their component particles from one another, and makes room for itſelf among them. It diminiſhes their mutual attraction; and dilates the bodies which they compoſe. It fuſes ſolids; and rarefies liquids to ſuch degree that they become inviſible, aſſume the form of air, and are thus converted into elaſtic, compreſſible, aeriform fluids. Liquids are therefore combinations of ſolids with caloric; gaſſes are ſolutions of diverſe bodies in caloric. Caloric is of itſelf, the moſt divided, the moſt attenuated, the lighteſt, and the moſt elaſtic of all the ſubſtances in Nature: And hence, its gravity cannot be eſtimated.

III. Caloric augments the mutual attractions of contiguous bodies, preciſely in the ſame proportion in which it divides, and diminiſhes the mutual attraction of the component particles of each of them. In conſequence of this, it is ſucceſsfully employed to effect new combinations; and to promote the reciprocal union of different bodies. Hence the axiom *corpora non agunt, niſi ſoluta; bodies act not on one another, unleſs previouſly diſſolved.*

IV. Every different body, having a form and an arrangement of its conſtituent particles peculiar to itſelf, requires a peculiar quantity of caloric, to heat it to any given temperature: which is called *its* particular *capacity for containing caloric.* From this it follows, that different bodies, even when of the ſame temperature, and when indicating the ſame degree of the thermometer, really contain different quantities of caloric.

V. That particular quantity of caloric, which each different body requires, to communicate to it any given temperature, is called its *ſpecific caloric.* And as the differences of this ſpecific caloric in different bodies, cannot be meaſured by the thermometer; there has been an *invention* produced, which meaſures the differences of ſpecific caloric in different bodies of the ſame temperature, by aſcertaining the quantity of ice, which each of theſe bodies melts, while falling from the ſame higher to the ſame lower degree of the thermometer. The differences of the quantities of melted ice, indicate the diverſities of ſpecific caloric in the different bodies thus compared. The inſtrument which this invention employs, is called a *Calorimeter.*

VI. All the experiments of thoſe modern philoſophers who have inveſtigated the theory of caloric, concur to prove, that bodies, when they change their ſtate, ſuffer alſo a change of their reſpective capacities for containing caloric. *By the change of the ſtate of bodies,* is meant, the alteration of their ſolidity, liquidity, or elaſtic fluidity. By the mixture, therefore, of any two ſolid bodies, of unequal temperatures, and not entering into mutual combination, but having the ſame capacity for containing caloric, we ſhall obtain a maſs of an exactly intermediate temperature. But if theſe two bodies be of unequal capacities for containing caloric, then the temperature of the mixture will not be preciſely intermediate between the temperatures of the two different bodies: And according as it recedes more or leſs from the preciſe intermedium, will the difference between the capacities of the two bodies be greater or leſs.

VII. The foregoing facts ſhew, that caloric has different attractions or degrees of affinity for different bodies. In all combinations, therefore, the varied attraction of caloric ought to be carefully obſerved, and eſtimated.

VIII. When bodies enter into mutual union, they either ſuffer a loſs of caloric; which ſhews the new compound to have a ſmaller capacity than its conſtituent parts had, for containing caloric; and in which caſe, the proceſs exhibits heat to our organs, and the temperature of the mixture riſes; as is the moſt common effect: Or elſe the bodies entering into combination, abſorb caloric; and the new compound contains more caloric, than its component parts contained when they were ſeparate; in which caſe, the mixed ſubſtances cool, while the combination is taking place; the caloric which was before diffuſed in a free ſtate among their component particles, is now more intimately combined with them; and there is even an abſorption of caloric from contiguous bodies.

IX. Caloric ſometimes adheres ſo tenaciouſly to particular bodies, as to hinder theſe from entering into combination with other bodies preſented to them. There are various ſubſtances, which, when rarefied to the ſtate of gazeous or elaſtic fluidity, neither unite with extraneous matters, nor with one another. Double affinities muſt be employed, if we wiſh to make them enter into new combinations, without having firſt changed their gazeous form.

X. So powerful is the attraction of caloric for certain bodies, that it is very often uſefully employed to detach thoſe bodies from compounds in which they are combined; and to analyſe or decompoſe a variety of compound ſubſtances. In diſtillation, and in proceſſes of decompoſition, effected by the aid of fire, the whole proceſs conſiſts in the application of fire or caloric to matters of an extremely compound nature. Theſe matters are thus gradually diſſolved; and their principles are ſeverally detached in a vaporous or gazeous form, and in the order of their ſolubility by caloric.

XI. It often happens, that light applied in conjunction with caloric, aids its operation, and *vice verſa.* Chemiſts find it advantageous to uſe tranſparent veſſels, which, when in the furnace, admit both light and caloric together. The effect is the ſame, when opaque veſſels are ſufficiently penetrated with caloric, to become red-hot, or permeable by light.

XII. Some bodies abſorb caloric much more rapidly than others: And this property of abſorbing caloric is termed rather *the conducting of caloric.* Thoſe bodies which are the moſt highly coloured, are in general the beſt conductors of caloric. But the cauſe of this phænomenon is unknown.

XIII. All theſe facts agree in proving, that caloric is a peculiar ſubſtance; not, as ſome philoſophers have ſuppoſed, a modification of all natural bodies. We know not, as yet, whether it be ſame with light. The farther we advance in the philoſophical knowledge of Nature, the more differences do we ſtill continue to diſcover between the action of the one of theſe bodies, and that of the other.

Application of the foregoing Axioms.

The Dilatation of ſolids; and the Rarefaction of fluids;
Thermometers;
Fuſion;
Sublimation, and Volatilization;

The Calorimeter; a table of the ſpecific caloric in different bodies;
The changes of temperature in different mixtures;
Artificial refrigeration;
The production, and the fixation of Gaſſes;
Diſtillation, with different temperature
Incandeſcence;
The different conductors of Caloric;
The attractions of Caloric.

CHAP. III.

The ACTION *of* AIR.

I. THE air acts in a maſs, upon all the other bodies in Nature, by its weight, its dryneſs or moiſture, its temperature, &c. Hence, proceſſes of combination or decompoſition to which air has free acceſs, differ greatly from thoſe performed *in vacuo*. And for this reaſon, it is always neceſſary, in chemical experiments, to pay careful attention to the indications of the barometer, the thermometer, and the hygrometer.

II. The atmoſphere is a vaſt laboratory in which Nature continually performs numberleſs proceſſes of analyſis, ſolution, precipitation, and combination. It is an immenſe recipient, in which all the attenuated and volatilized products of terreſtrial bodies, are received, agitated, mingled, combined, or ſeparated. The air of the atmoſphere may thus be regarded as a vague and confuſed mixture of mineral vapours, of minute particles of bodies animal and vegetable, of ſeminal grains and eggs; through which the luminous, the caloric, and the electric fluids, inceſſantly paſs and repaſs in all directions. Thoſe great changes to which it is liable; the operation of each of which, extends at once through a wide tract of ſpace, and which are exhibited to our ſenſes, in the production of water, light, free caloric, and noiſe; have received the name of *Meteors*.

III. Although of a compoſition ſo extremely mixed, and ſeemingly uncertain; yet is the air of the atmoſphere, to our perceptions, the ſame in its primary qualities, whatever the place from which the ſpecimen is taken. Its particular character is diſtinguiſhed by its two moſt eminent properties—of *maintaining combuſtion*, and *being fit for* the ſalutary *reſpiration* of animals. Theſe two grand phænomena are ſo nearly allied to each other, that a diſtinct knowledge of the nature of air, may be obtained by the careful obſervation of what paſſes in the caſe of combuſtion.

IV. A combuſtible body will not burn, unleſs it be in contact with atmoſpheric air, or with a certain ſubſtance extracted from atmoſpheric air. Combuſtion cannot take place *in vacuo*.

V. In any given quantity of air, a combuſtible body can burn only for a certain proportionate ſpace of time. An hundred parts of atmoſpheric air, contain only twenty-ſeven parts that can contribute to combuſtion. After a combuſtible body ſhall have abſorbed theſe twenty-ſeven parts, the combuſtion will then ſtop; becauſe the remaining ſeventy-three parts can be of no uſe to promote it. Atmoſpheric air is a compound of two different ſubſtances; having only ſome other extraneous matters mingled with it; which do not exceed an hundredth part of the whole. Of thoſe two component principles of atmoſpheric air, *one* ſerves for the purpoſes of combuſtion and reſpiration, and is called *Vital Air*; the *other*, differing from vital air, in poſſeſſing qualities directly contrary to *its* two moſt eminent ones, is called *Gas Azote*.

VI. A body burning in common air, therefore, actually analyſes this fluid; detaches the vital air; and by abſorbing it, gains an increaſe of weight, and undergoes a change of nature. The gas azote that remains, is lighter than atmoſpheric air; extinguiſhes combuſtion; and deſtroys animal life; and is, as we ſhall hereafter ſee, a principle in the compoſition of many bodies, particularly of ammoniac or the volatile alkali, of the acid of nitre, and of animal ſubſtances.

VII. A combuſtible body, after being burnt in atmoſpheric air, and abſorbing as much vital air, as it is capable of receiving into combination with it; cannot again burn, although it be immerſed in freſh air; but has become incombuſtible, and generally ſaline.

VIII. A body burning in atmoſpheric air, never entirely abſorbs the ,27 parts of vital air. To detach the whole of the vital air, from any quantity of the air of the atmoſphere, and thus to accompliſh a complete analyſis of the latter; combuſtible bodies muſt be repeatedly immerſed in it, and the combuſtion renewed for ſeveral different times in ſucceſſion.

IX. That portion of air which is thus abſorbed by combuſtible bodies, and which we have hitherto named *Vital Air*, is likewiſe denominated *Gas Oxigene*. It has received the *firſt* of theſe names, becauſe it is the only elaſtic fluid fit for the ſalutary reſpiration of animals. The *ſecond* has been affixed to it, becauſe many bodies are, by the abſorption of it, rendered acid.

X. Combuſtion conſiſts, then, in the fixation and abſorption of vital air by combuſtible bodies, and in the decompoſition of atmoſpheric air by theſe bodies. Since no elaſtic fluid but vital air, can act the ſame part in combuſtion; it is eaſy to conceive, that a body which is ſufficiently combuſtible to abſorb all the vital air out of a given quantity of atmoſpheric air; may be employed as a means of aſcertaining the preciſe proportions in which the two elaſtic fluids of the atmoſphere are combined together in it. Phoſphorus is, upon this principle, at preſent uſed as an *Eudiometer*, to indicate the purity of air, that is, to ſhew what proportion of vital air it contains.

XI. As vital air is a *Gas,* and many combuſtible bodies, by abſorbing, fix it, and make it take a ſolid form; it muſt neceſſarily happen, that vital air, when thus precipitated, will loſe the caloric to which it owed its elaſtic fluidity. Hence comes that free caloric or heat, which is evolved during combuſtion.

XII. Combuſtible bodies differ from one another, 1. In the degrees of rapidity, with which they reſpectively abſorb oxigene; 2. In the quantities of oxigene which they reſpectively abſorb; 3. In the proportions of the caloric which they ſeverally diſengage from the oxigene abſorbed; 4. And conſequently, in the more or leſs perfect ſolidity of the oxigene contained in them all, after combuſtion.

XIII. Burnt bodies may therefore be defined to be *bodies combined with oxigene.* They are called alſo, *oxigenated* or *oxidated ſubſtances.* And ſince the greater part of thoſe bodies which are known to us, are either *burnt* or *combuſtible;* there is reaſon for thinking, that a number of incombuſtible natural bodies, the compoſition of which is unknown, may poſſibly be hereafter found to be incombuſtible, only becauſe they are already ſaturated with oxigene. In ſeveral inſtances, this conjecture has been already confirmed by the progreſs of chemical diſcovery.

XIV. From ſeveral of theſe preceding axioms, it follows, that when we burn a combuſtible body, that it may give us heat; as, in our domeſtic apartments, in the cold of winter; we derive, not from the combuſtible body, but from the air itſelf, the greater part at leaſt, of the caloric which exiſts in combination with it. [It may even be aſſerted, that the colder the air, ſo much the more heat does its decompoſition afford; for the colder the air is, the more is it condenſed; and ſo much the greater is its quantity in proportion to its bulk. We know, that the heat of our common fires becomes much more lively and intenſe, when the ſurrounding air is ſuddenly cooled. The art, too, of increaſing combuſtion by pouring a ſtream of freſh air, with bellows, upon wood already inflamed, is founded upon this principle *.]

XV. Combuſtion, therefore, decompoſes not only atmoſpheric air, by the abſorption of one of its principles; but alſo the vital air abſtracted, by abſorbing, fixing, and ſolidifying more or leſs, the oxigene or baſe of the vital air, in the combuſtible body; and by diſengaging in greater or ſmaller abundance, the caloric which was the ſolvent of that baſe.

XVI. Combuſtion exhibits another intereſting phænomenon which has been explained by modern chemiſtry. This

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* The Author ſeems here to miſrepreſent, or to expreſs obſcurely, the true chemical fact. *Cool air* is cold and denſe, only for want of caloric, to rarefy and warm it. Before the *caloric* can eſcape, and the *oxigene* enter into combination with the *burning body*; the *vital air* muſt ever be ſaturated with *caloric*, to that point at which the *attractions* of *oxigene* for the *combuſtible body*, and of *caloric* for other contiguous ſubſtances, are ſufficient to overcome the mutual attraction by which *caloric* and *oxigene* are held in union, in *vital air*. Now, one combuſtible body may indeed have a more powerful attraction for *oxigene* than another; *oxigene* may have abſorbed *caloric* beyond the due point of ſaturation: And hence will the quantity of *caloric* vary, which is neceſſary to fit *vital air* for ordinary *combuſtion*. But this variation is never ſuch as the author ſeems in the text to ſuppoſe. Cold air is always rarefied by the abſorption of a new quantity of the ſurrounding free caloric, before it enters into combuſtion. A ſtream of denſe, cold air, revives and inflames combuſtion,—ſolely by the more rapid *mechanical* expulſion of the freed *gas azote*; by the abſorption or expulſion of the evolved caloric, which would otherwiſe have floated about, ſo as to make the proceſs languiſh; and by a removal of the aſhes, or the new compound of the combuſtible body and oxigene, in conſequence of which, freſh parts of the combuſtible body, are expoſed to the contact of the vital air. The action of *bellows* in promoting inflammation, is thus almoſt wholly mechanical.—In reading thoſe ſentences of the text which I have incloſed within brackets, it is to be carefully remembered, that, *cold air does not neceſſarily contain more caloric, than the ſame bulk of hot air may contain*; but only has *a capacity of containing more*; which muſt *commonly be more or leſs ſatisfied, before it can be decompoſed by combuſtion*. H.

is the diſengagement of light, or the production of flame. It is certain, that the greater part of the light which conſtitutes flame, is contained in vital air, of which it is a component principle: 1. Becauſe combuſtible bodies yield much more flame, when they burn in vital air alone, than in atmoſpheric air: 2. Becauſe ſome combuſtible bodies afford no flame, unleſs when burning in pure vital air: 3. Becauſe, in order to abſtract oxigene out of bodies containing it, for the formation of vital air; it is neceſſary not only to diſſolve the oxigene in a greater or ſmaller quantity of caloric, but alſo to add, at the ſame time, a due portion of light: 4. Laſtly, Becauſe there are burnt bodies, which, at the bare contact of light, are deprived of their oxigene. The laſt of theſe four facts is expreſſed by the terms, *unburning* and *decombuſtion*; phænomena which were ſaid, in the firſt chapter, to be produced by the action of light.

XVII. Vital air is therefore a compound of *oxigene*; a ſolidifiable, ponderous, acidifying baſe; held in ſolution by *caloric*, and *light*; which are of themſelves ſubſtances in a ſtate of extreme attenuation, extremely elaſtic, and having no meaſurable gravity. Combuſtion conſiſts in the more or leſs perfect precipitation of oxigene from its union with theſe its two ſolvents.

XVIII. A combuſtible body, then, when burning, diſengages from vital air, not only caloric, but light alſo. Every different combuſtible body diſengages its own peculiar portion, as well of light as of caloric, from vital air. There are probably ſome combuſtible bodies which diſengage more of caloric than of light from vital air; and others again which diſengage from it more of light than of caloric.

XIX. Oxigene that is fixed in burnt combuſtible bodies, is therefore more or leſs entirely deprived of its light and caloric. The denſity, the ſolidity, which it then acquires, is one of the cauſes that regulate the more or leſs eaſy ſeparation of oxigene from burnt, combuſtible bodies, for the formation of

new

ew vital air. Some of theſe bodies require, in order to this, more of light than of caloric, while others take more of caloric than of light.

XX. From what is here ſaid, it is eaſy to conceive, that the abſtraction of oxigene from a burnt body, is a proceſs directly the reverſe of combuſtion. Our language wants a word to expreſs this operation. It may be ſaid to *unburn* or *deoxidate* bodies: And hence we may derive *unburning* or *deoxidation*, as names to denote the event accompliſhed.

XXI. Oxigene, beſide adhering more or leſs tenaciouſly to combuſtible bodies, according as it is in its union with them, more or leſs ſolid, and has loſt more or leſs of its ſolvents, caloric and light; is alſo attached to thoſe bodies by virtue of its attractions, or peculiar affinities for every different one of them reſpectively. We are already acquainted with many of theſe affinities of oxigene, for different bodies: And of ſome of them, the preciſe forces even, have been correctly aſcertained.

XXII. By means of theſe affinities, we often make oxigene to paſs from a burnt, into a combuſtible body. A ſpecies of combuſtion then takes place, which is more or leſs tacit and ſecret, in proportion as the oxigene is more or leſs ſolid in its combination with the burnt body, and more or leſs in the ſame ſtate of denſity, as the ſubſtance into which it is paſſing. But this ſpecies of combuſtion is ſometimes accompanied with vivid flame and heat; phænomena which are exhibited, whenever the body which receives the oxigene, requires it in a ſtate more ſolid than that in which it exiſted in the ſubſtance now diveſted of it. Thus iron, zinc, antimony, arſenic, &c. burn with flame, when heated in contact with oxide of mercury: They rob this oxide of its oxigene, and require the oxigene to become more ſolid, as it enters into combination with them.

The foregoing propoſitions may be applied to explain

The reſiſtance which the air makes to evaporation, to the ebullition of liquids, to ſublimation, &c.;

The ſolution of water in air, and the variations of the dryneſs and moiſture of the atmoſphere;

The efloreſcence and deliqueſcence of ſaline bodies;

Aqueous meteors;

Experiments made at different heights in the atmoſphere;

Experiments made *in vacuo;*

The comparative natures of combuſtible bodies;

The increaſe of the weight, and the change of the nature of theſe bodies after combuſtion;

The hiſtory of native burnt bodies;

Artificial flame and heat;

The theory of furnaces;

The different proceſſes performed with *Eudiometers*, for aſcertaining the degree of the purity of air;

The reſpiration of animals;

The reduction of air to a mephitis by the effects of combuſtion and reſpiration;

The ſupport, diminution, and augmentation of animal heat;

Tranſpiration from the ſkin and from the lungs, &c.

CHAP. IV.

The NATURE *and* ACTION *of* WATER.

I. WATER exiſts in three different ſtates. It is *ſolid* in *ice;* it is beſt known as a *liquid;* it is expanded by rarefaction into *vapour* or *gas.*

II. Ice is a cryſtallization more or leſs regular, tranſparent, highly ſapid, elaſtic; fuſible at a temperature above 32° Fahrenheit; and which when entering into ſeveral new combinations, ſtill gives out caloric, notwithſtanding its previous apparent deſtitution of heat.

III. Ice of the temperature of 32° of Fahrenheit's thermometer, requires to its fuſion, preciſely that quantity of caloric which would be ſufficient to raiſe an equal quantity of water to the temperature of 167° Fahrenheit. Its capacity for containing caloric, is therefore not preciſely the ſame as that of liquid water: a difference owing to the peculiarity of the ſtate of ice; as has been explained in the VI. Section of the II. Chapter.

IV. Whenever liquid water loſes much of its heat, in entering into a new combination; it may be conſidered as becoming ſolid. In ſuch combinations, it is often more ſolid than ice at the temperature of 32° F. Hence the ſolidity of mortar, and other cements made with ſlaked lime.

V. Water remains eternally ſolid, on various mountains which have been for ages chilled by the preſence of ice, as well as under the poles. It there forms a ſort of rocks, or hard and white concretions, not unlike to ſtones.

VI. Liquid water is pure and taſteleſs, without ſmell, and 850 times as heavy as an equal bulk of air. It forms rivers, lakes, ponds, ſprings, brooks, &c. It occupies cavities, furrows, and in general all the loweſt parts of the ſurface of the globe.

VII. It is rarely pure. At the ſurface, and in the interior parts of the earth, it diſſolves and retains air, ſaline gaſſes, and terrene ſalts. It even acts upon the moſt ſolid ſtones, wears them down by attrition, depoſites the particles which it carries with it, and forms them into cryſtallized figures. It has been, on this account, named the great ſolvent of nature. It gives riſe to many phænomena; and is one of the prime agents which are for ever modifying anew the ſurface of the globe. Its motions, its currents, its action, have at length changed the nature of minerals, and have created, as it were, a ſort of new world, upon the old.

VIII. All waters on the earth contain, therefore, ſome extraneous ſubſtances. The preſence of theſe may be recognized by the extraordinary ſpecific gravity of the water; by its taſte being more or leſs inſipid, earthy, and crude; by its averſion to boil, and its inability to ſoften pulſe, or to frothe ſoap. That water is the moſt pure, which is the fartheſt from poſſeſſing theſe qualities.

IX. Water, running over a bed of quartzoſe ſand, and in contact with air, is ſufficiently pure for the ordinary purpoſes of life, and of the arts. But, water which paſſes through chalk, plaſter, or marble, or which ſtagnates over *peat-earth*, bitumen mineral ores, or in ſubterraneous caverns, at a diſtance from the action of the atmoſphere; is always more or leſs impure.

X. Chemiſtry corrects the impurity, crudeneſs, and hardneſs of waters, by expoſing them to the air, agitating them in contact with it, by boiling, diſtilling, and then *aerating* them. The addition of aſhes, alkalis, and light acids, ſerves to remove in part, the bad qualities of water, and ſometimes even deſtroys thoſe qualities altogether. Moſt of thoſe extraneous bodies by which the purity of water is altered, being either much more volatile, or much more fixed in their nature than water; diſtillation is therefore the ſureſt means for purifying water. Chemiſts, for this reaſon, uſe always diſtilled water in their experiments.

XI. As liquid water is a combination of ice of the temperature 32° F. with ſuch a portion of caloric as would be ſufficient to raiſe a quantity of water equal to the quantity of ice employed, to the temperature of 167° F.; therefore caloric added to liquid water, rarefies it. At 212° F. water takes a gazeous form, and is diffuſed in vapour. This vapour is much lighter, and in proportion to its actual weight, is expanded into a much greater bulk, than liquid water. It eaſily penetrates through all other bodies, and is diſſolved in air. The elaſtic efforts which it makes to expand itſelf, whenever it experiences an increaſe of temperature, fit it for moving the largeſt bodies.

XII. As liquid water abſorbs air, and thus becomes lighter; ſo air alſo abſorbs and diſſolves water. Hence the evaporation of water. This ſolution of water in air is dry and inviſible, like the air; it follows the ratio of the temperature of the atmoſphere. The hygrometer does not accurately indicate the preſence of water in this ſtate; for a perfect ſolution of water in air, does not at all affect that inſtrument. But water about to be diſſolved in air, and ſtill more water precipitated from this ſolution, never fail to alter the indications of the hygrometer.

XIII. Water is not, as it was long ſuppoſed to be, a ſimple body. Upon the rapid combuſtion of various combuſtible bodies, more or leſs intenſely heated; ſuch as charcoal and pitcoal, both previouſly kindled, iron red-hot, zinc in fuſion and red-hot, oils, &c.; water preſented to theſe bodies in this ſtate, undergoes a decompoſition; and a quantity of oxigene derived from it, is fixed in the combuſtible bodies.

XIV. While the *oxigene* from water *is fixed* in thoſe combuſtible bodies which it kindles and inflames; the other component principle of the water, being ſuſceptible of ſolution in caloric, forms *inflammable gas*, which is diffuſed in an uncombined ſtate. This ſecond ſubſtance, as being one of the elementary principles of water, has been named *hydrogene;* and its elaſtic fluid ſolution in caloric and light, has been called *gas hydrogene.* That diſengagement of this ſubſtance into gas, which takes place whenever water is decompoſed by a combuſtible body, is the cauſe of a great number of detonations and fulminations.

XV. The gas hydrogene obtained in very many chemical proceſſes, comes always from water; *either* radically, and by the effect of a former decompoſition, by which the hydrogene has been abſtracted from water, and fixed in ſome other body which now reſigns it; *or* by the immediate and inſtantaneous decompoſition of water itſelf.

XVI. It has been aſcertained by many experiments, that water contains about 0,85 of oxigene, and 0,15 of hydrogene. The compoſition of water by a chemical proceſs; one of the nobleſt diſcoveries of modern chemiſtry; confirms the certainty of the analyſis of water. For, 0,85 parts of oxigene, added to 0,15 of hydrogene, give ,100 parts of pure water.

XVII. The decompoſition of water by a combuſtible body, is always effected by the double affinities—of the oxigene of the water for the combuſtible body, and of caloric for the hydrogene of the water. On this account, the greater the quantity of the caloric matter employed ; ſo much the more rapid is always the decompoſition of water by iron, charcoal, &c. From this need of a great abundance of caloric, in this proceſs, an idea may be drawn, of the manner in which hydrogene, one of the component principles of water, comes to acquire a degree of levity ſo much greater than that of the water in which it before exiſted : A cubic foot of water weighing 70 lib.; while a cubic foot of gas hydrogene, weighs only 61 grains.

XVIII. Gas hydrogene, which is always *originally* derived from the decompoſition of water ; carries with it, uſually a conſiderable portion of the body with which it was laſt combined ; and this either in ſuſpenſion or ſolution, according as that body was of a nature more or leſs mixed. It is commonly mixed with gas azote, with carbonic acid gas, or with vital air ; or it holds in ſolution, water, carbone, ſulphur, phoſphorus, arſenic, oils, alcohol, æther, &c. According as its purity is contaminated by one or another of theſe different ſubſtances ; it varies in odour, gravity, inflammability, the colour of its flame, its action upon different ſubſtances, and the extraneous products which, beſide pure water, it affords, when burnt. Hence all the different ſpecies and names of inflammable gas, the generic baſe of which, is always gas hydrogene.

XIX. Gas hydrogene being one of thoſe natural ſubſtances which contain the moſt caloric ; is one of thoſe combuſtible bodies which the moſt eaſily ſuffer their caloric to eſcape ; and which, by conſequence, afford the moſt heat, when burning. Hence, all compound, inflammable matters ; ſuch as oil, greaſe, and in general all thoſe which are obtained from organized bodies ; having hydrogene for one of the moſt abundant principles in their compoſition ; yield much heat, during their combuſtion. Of this character, are alſo timber, oils, pit-coal, bitumen, alcohol, æther, &c.

XX. It follows alſo from the preceding facts, that compound, combuſtible bodies, containing much hydrogene in their compoſition; muſt require, when they burn, a very large proportion of oxigene, and will afford water, as a product of their combuſtion, in juſt proportion to the quantity of hydrogene which they contain. Thus a pound of alcohol gives by combuſtion, more than a pound of water, &c.

XXI. The combuſtible bodies that decompoſe water, are in general, thoſe which have a ſtronger attraction for oxigene, than hydrogene has. But the efficacy of this attraction is greatly aided by the preſence of caloric, which for its part, tends to combine with hydrogene. Great abundance of caloric, may even render water decompoſable by bodies, which, if cold, would be unable to decompoſe it. Light alſo contributes to the ſame effect.

XXII. Combuſtible bodies which, at whatever temperature, do not decompoſe water, on account of the faintneſs of their attraction for oxigene; which is in this caſe always weaker than the attraction between oxigene and hydrogene;—will, on the contrary, after being burnt by other means, undergo decompoſition by ſuffering hydrogene to abſtract the oxigene which they had acquired, when burning. This happens to the oxides of lead, biſmuth, &c.

XXIII. Chemiſtry knows, as yet, no other means of decompoſing water, but by preſenting to it, combuſtible ſubſtances capable of detaching and abſorbing its oxigene. We are acquainted with no bodies that we can apply in art, to abſorb the hydrogene, and leave the oxigene diſengaged. Nature, however, poſſeſſes inſtruments by which ſhe can accompliſh this particular decompoſition of water. The leaves of vegetables, when the rays of the ſun fall upon them, ſeem to decompoſe water, to abſorb its hydrogene, and to evolve its oxigene into vital air. This appears to be, in part, the mechaniſm of vegetation, of the formation of oils, and of the renovation of the atmoſphere. See Chap. IX.

XXIV. While hydrogene and oxigene, diſſolved each into into gas by the efficiency of caloric and light; remain both cold; they cannot combine, although brought into mutual contact: no inflammation is produced by their mutual impulſe; there is no water formed. But when a burning body is preſented to the mixture, when it is powerfully compreſſed, or if it receive any ſudden and violent ſhock: the two gaſſes then begin to unite; combuſtion enſues; and water is produced.

XXV. It ſhould ſeem, that a like event happens in the atmoſphere. Detonations in the air, or claps of thunder, are probably nothing elſe but the combuſtion of hydrogenous gas with vital air; and are accordingly followed, for the moſt part, by heavy ſhowers of rain. Other tempeſtuous rains appear alſo to be owing to the ſudden formation of water in the atmoſphere; in conſequence of the rapid combuſtion of hydrogenous gas and vital air; occaſioned by the electric ſpark, and by the neceſſity for reſtoring the electric equilibrium between one cloud and another, or between the clouds and the earth.

XXVI. A multitude of chemical phænomena in nature and art, that ſeemed formerly to be unaccountable and miraculous; are now perceived to be neceſſary conſequences of the decompoſition of water. The influence of the general facts enumerated in this chapter, is very great, upon the whole theory of chemiſtry. They will recur to our notice in all the ſubſequent chapters.

Application of the preceding propoſitions.

Artificial refrigeration;
Theory of icy mountains, and of the polar ices;
Varieties of the waters of the earth and atmoſphere;
Art of correcting the bad qualities of water;

Theory of the ebullition of water;
Difference between boiled and aerated water;
Diſtillation of water in large quantities;—of ſalt water;
Theory of miſts and dews;
Theory of the hygrometer; and of the phænomena meaſured by it;
Inflammation of combuſtible bodies by water;
Gaſſes diſengaged from the waters of marſhes;
The diverſity of inflammable gaſſes;
Colouring by inflammable gaſſes;
The oxidation of metals, or ruſt formed by moiſt air;
Theory of detonation;
Some of the phænomena of the ſolution of metals;
Some fundamental principles towards a theory of vegetation, of the formation of oils, &c.

CHAP. V.

The Nature and Action of EARTHS *and* ALKALIS.

I. WHAT was formerly meant excluſively by the name of *Earth*; and was ſuppoſed to be an *elementary* ſubſtance, the cauſe of ſolidity, dryneſs, inſipidity, inſolubility, &c.; is no longer to be regarded in any other light, than as one of thoſe vague, indeterminate ideas, which the imagination diſſatisfied with the fruitleſsneſs of experiments, often frames to amuſe it, inſtead of facts. We now acknowledge no ſuch thing as *elementary* earth. Inſtead of one, we have attained to the knowledge of five terrene ſubſtances; each of which has an equal right to be termed *elementary*, ſince each of them is found to enter into very many compounds.

II. Of the five ſimple terrene ſubſtances which have been diſcovered, there are two in ſome ſort more eminently earthy than the reſt, more dry, more ſuſceptible of hardneſs, more inſipid, &c. The other three poſſeſs ſaline qualities which give them a ſimilarity of nature, to alkaline ſubſtances. Theſe laſt three have been therefore denominated *Salino-terrene*, *ſaline earths*, *alkaline earths*, *terrene alkalis*. The two firſt are *ſilices* and *alumines*. The latter three are *barytes*, *magneſia*, and *lime*.

III. Each of theſe five earths, is diſtinguiſhed by *ſpecific* characters, beſide thoſe *generic* qualities which belong to all the five, in common. Their generic characters are, dryneſs, unalterability by fire, the property of not being liable to decompoſition, and of acting, in combinations, as ſimple, indeſtructible ſubſtances.

IV. *Silices*, has been named alſo *ſiliceous earth*, *quartzoſe earth*, *vitrifiable earth*. It is rough to the feeling of the hand: it ſcratches and wears down metals; it is infuſible, and incombuſtible; inſoluble in water or acids—at leaſt the greater number of acids; it is ſoluble by alkalis, when expoſed in contact with them, to an intenſe heat, and in conſequence of this ſolution, forms with them a glaſs. This ſimple earth is found in great abundance, in ſand, quartz, flint, agate, jaſper, grit, and in all ſcintillating ſtones, which, indeed, have it for their baſes. It has not, as yet, been either decompoſed, or imitatated by ſyntheſis. It has been conſidered as the ſimpleſt of all earths, the element of earth, the principle of every other ſort of earth: but theſe opinions have not hitherto been juſtified by obſervation or experiment. It is applied to a multiplicity of uſes, for mill-ſtones, the manufacture of glaſs, cements, pottery, &c.

V. *Alumines*, ſo named, becauſe it forms the baſis of alum, is called alſo *Argill*, by ſome writers. It is ſoft to the finger, adheres to the tongue, forms a paſte with water, hardens in the fire. It combines with moſt acids, dries into flakes, and aſſumes extraordinary hardneſs when mixed with water and *ſilices* together. It is contained in a large proportion, in common clays, in pipe-earth, in ſchiſtus, ſteatites, &c. In many of the arts it is employed, as a ſubſtance adapted to receive and retain any artificial form, which may be baked by the fire, and which is fit to reſiſt the penetration of water. Its intimate nature or component principles are unknown; it has been erroneouſly regarded, as *ſilices* altered, divided, and mouldered down by the action of air and water.

VI. Barytes, or *ponderous earth*, is a ſubſtance remarkable for its extraordinary gravity. In nature, it is never found alone, but always in combination with the ſulphuric or the carbonic acid. It takes a green or blue colour, when expoſed to the action of fire, in contact with the ſilices, or alumines of the crucible. In nine hundred parts of water, it diſſolves; it communicates a green colour to the ſyrup of violets; it has a greater affinity than even the alkalis with moſt of the acids; its origin is unknown; but it is ſuſpected to be a metallic oxide; it ſerves, at all times, to detect the preſence, and aſcertain the quantity of the ſulphuric acid.

VII. Magneſia is a ſubſtance very fine and white; not ſubject to alteration by fire; ſoft and light; it reſembles the feculum of vegetables, and requires nearly two thouſand parts of water to diſſolve it. It communicates but a faint greenneſs to the tincture of violets and mallows; with acids, it forms ſalts which are very ſoluble, and in which the magneſia is combined with a force of attraction ſo much leſs than that with which lime adheres to acids, that they are all liable to be decompoſed by lime. The attraction of magneſia for the acids; is nearly the ſame as that of ammoniac; accordingly ammoniac and magneſia entering together into combination with acids, thus form a claſs of triple-ſalts, or ſalts with two baſes. This earth exiſts in a ſufficiently perceptible proportion, in ſerpentines, mica, ſlate, amianthus. Like the preceding earths, it is indecompoſable, and of unknown compoſition.

VIII. Lime, the moſt alkaline of all the earths, is the only one that has an acrid taſte, hot, almoſt cauſtic, diſagreeable, and urinous. It gives a dark-green tinge to ſyrup of violets, and when ſlaked in the open air, attracts moiſture from the atmoſphere. Under the action of water, it becomes exceedingly hot, and abſorbing the water, becomes ſolid, in combination with it. When ſlaked barely by expoſure to the atmoſphere, it gives out caloric, largely: it is ſoluble in leſs than ſeven hundred times its own weight of water. Diſſolved, it attracts carbonic acid from the atmoſphere; and on the ſurface of the ſolution, forms a pellicle of chalk which has been improperly termed *Cream of Lime*. Alone, it is unalterable by fire; but with ſilices and alumines, is reducible to fuſion. It is plainly a compound; but its component principles are unknown.

IX. That earths are occaſionally converted into one another, is merely a vain dream of naturaliſts. We have no proofs, that ſilices is by long expoſure to the air, changed into alumines; that flints are transformed into chalk; that chalk is converted into magneſia; as has been too haſtily inferred from ſome ſlight and caſual appearances.

X. The three alkaline earths have more the appearance of being compound, than magneſia or lime. We have reaſon to believe, that azote is one of their component principles; and that they owe to it their alkaline properties. Yet this opinion has not hitherto, been ſufficiently confirmed by experiments. The formation of the alkalis, is, indeed, with great probability, aſcribed to marine animals; and the fact that theſe contain much azote, ſeems to ſuggeſt, that azote is the grand alkaligenous principle in Nature.

XI. It has been ſuppoſed, that the five earths are of a metallic nature; and it has been pretended, that by violent ignition with charcoal, their reduction into the metallic ſtate, has been effected. But thoſe very few, and very ſmall metallic globules which have been in ſuch inſtances obtained, came evidently from the charcoal, and from the earth of the cupels: and thoſe having been diſcovered to be phoſphure of iron, whatever the earth in the treatment of which they were procured; it is hence evinced, that the earths afford no metallic matters. Some philoſophers indeed continue to regard the earths, as a ſpecies of burnt bodies, in which oxigene is extraordinarily adheſive; and which, on account of this adheſion,

heſion, cannot be decompoſed. But, this opinion is, as yet, unconfirmed by obſervation or experiment.

XII. Earths combine with one another; two and two, three and three, and even in compoſitions more complex; by proceſſes unknown to us, but which Nature continually accompliſhes in the great way; by them, producing ſtones various in hardneſs, ſtructure, tranſparency, opacity, colour, form, &c. Art cannot imitate theſe compounds, for want of time, of ſufficient maſſes of the materials, and of an adequate extent of ſpace. Yet it produces ſomething ſimilar to the natural compounds of the earths, by preſerving long in mutual contact, mixtures of the earths, which have been well wrought together, and at the firſt, moiſtened with a little water.

XIII. The three alkaline earths hold an intermediate place between the earths and the alkalis; and are allied alike to both. The alkalis are known by their acrid, burning, urinous taſte, their cauſticity, their peculiar action on the ſkin and all other animal matters, their converting the blue colour of violets to a green or even a greeniſh yellow, and their deliqueſcency. The known ſpecies of alkali, are three, potaſh, ſoda, and ammoniac. Of theſe, the two former are named *fixed alkalis;* becauſe they melt and become red in the fire, before being volatilized: the third, as being in this reſpect, of an oppoſite nature, is termed *volatile alkali.*

XIV. Potaſh is known by the following characteriſtics. It is dry, ſolid, white, cryſtallized in rhomboidal plates, fuſible at the temperature of 235°, extremely deliqueſcent; it abſorbs water with the evolution of heat, and a peculiar, faint odour; by fuſion, it combines very well, and forms a tranſparent compound with ſilices. In nature, it is often found with lime, and in combination with different acids. It is obtained more eſpecially from vegetables; in the aſhes of which it remains, after their combuſtion. It has been thought to have ſuch a reſemblance to lime, that it might poſſibly be formed by the combination of that ſubſtance with azote. But this opinion is unconfirmed by experiment.

XV. Soda is obtained by the incineration of marine plants, and forms alſo the baſis of common ſea-ſalt. It has a remarkable reſemblance to potaſh in its form, cauſticity, fuſibility, deliqueſcency, its fuſion with ſilices, its action upon animal matters, &c. It long was, and ſtill might be confounded with potaſh. But the neutral ſalts which potaſh forms in combination with acids, are entirely different from thoſe which ſoda forms with the ſame acids. Soda has been ſuppoſed to be a compound of magneſia with azote; becauſe ſalts with a baſe of magneſia, are as often found together with ſalts which have ſoda for their baſe, as calcareous ſalts, with ſuch as have for their baſe, potaſh. But neither the one idea nor the other, is well founded.

XVI. Ammoniac or *volatile alkali*, differs greatly from the two preceding ſpecies. Its form is gazeous and peculiar, when it is diſſolved in caloric; diſſolved in water, it has a liquid form equally peculiar; its odour is lively and ſuffocating; it is ſoluble in the air; it is known to be eaſily decompoſable by the electric ſpark, by metallic oxides, and by the nitric, or the oxigenated muriatic acid. This decompoſition has ſhewn ammoniac to be a compound of hydrogene with azote; and in conſequence of this circumſtance, it often exhibits the phænomena of a combuſtible ſubſtance. This alſo explains the reaſon why animal matters under putrefaction, give out ammoniac.

XVII. Should azote hereafter be aſcertained to be the principle to which alkalis owe their formation; the atmoſphere will then appear to be a compound of *oxigene* and *alkaligene* each diſſolved, ſeparately, in caloric. It will appear to be a vaſt reſervoir, out of which the philoſopher may behold nature drawing the materials of the two claſſes of compound agents which are the moſt active, and the moſt uſeful, in very many of her operations.

The

Application of the Propoſitions in this Chapter.

The extraction, the preparation, and the purification of earths.

The theory of the arts of making earthen-ware, bricks, tiles, pottery, porcelain;

The theory of cements and mortars;

The reciprocal combinations of earths by fire;

The natural hiſtory of earths and ſtones;

The compound nature of earths and ſtones;

The natural alterations of ſtones;

The changes of colours by the alkalis;

Vitrification, and the proceſſes of the glaſs-maker;

The extraction and purification of potaſh and ſoda;

The theory of alkaline cauſtics;

Some particulars relative to putrefaction.

CHAP. VI.

The Nature of COMBUSTIBLE BODIES.

I. COMBUSTIBLE bodies are too numerous, various, and important in the phænomena which they preſent, and the combinations with one another and with air, into which they continually enter; not to deſerve to be examined with the utmoſt care, in order to the diſcovery of their different properties and ſpecific characters.

II. Comprehending under this denomination, all ſubſtances that are capable of entering, more or leſs rapidly into union with oxigene, and of diſengaging from vital air, its light and caloric: We muſt next diſtinguiſh thoſe ſubſtances into two claſſes; ſimple or undecompounded, combuſtible bodies; and thoſe combuſtible matters which are, in their nature, more or leſs compound.

III. We call thoſe combuſtible ſubſtances, ſimple, which chemiſtry has not hitherto been able either to decompoſe, or to form ſynthetically. Their intimate nature is unknown. They are found ſometimes ſolitary, in the mineral kingdom, or in the two other kingdoms of nature; but almoſt always combined two and two together. Of this character are diamond, hydrogene, ſulphur, phoſphorus, carbone, and all metals.

tals. Each of theſe ſix genera, is worthy of being examined by itſelf.

IV. *Diamond* is the hardeſt of all bodies. It is very remarkable for the force with which it refracts and decompoſes light; and from which NEWTON inferred, that it was highly combuſtible. In nature, it exiſts cryſtallized in octohædra, duodecahædra, &c. It has ſome varieties of contexture, denſity, and colour. It burns with a perceptible flame; and while it burns, is reduced to vapour. Its combination with oxigene is ſtill unknown. Few bodies act upon it; were it not for its combuſtibility, it might be ſuppoſed abſolutely unalterable. We know of no compound bodies into which it enters, as a component principle: of all the bodies in nature, it ſeems to be the leaſt ſubject to chemical attraction.

V. *Hydrogene* is one of the component principles of water; and in combination with caloric and light, forms gas hydrogene. The weight of this gas is to that of atmoſpheric air, as *one* to *ſixteen*. It is inſoluble in moſt other ſubſtances; but, on the contrary, diſſolves ſulphur, phoſphorus, carbone, arſenic, oils, &c.; and by theſe ſolutions forms various ſorts of inflammable gas; which are at preſent named *ſulphurated, phoſphorated, carbonated, arſeniated, oleaginous, &c. hydrogenous gas.* It decompoſes ſeveral metallic oxides, and ſome acids, of which the *radical* principles are ſimple and well-known. To all its compounds, whether combuſtible or incombuſtible, it communicates a conſiderable refringent power. Becauſe water poſſeſſed this power of refraction, NEWTON ſkilfully conjectured, that it muſt contain ſome ſuch combuſtible ſubſtance, as this which has been at laſt diſcovered in its compoſition. Hydrogene is alſo fixed in organic bodies, and forms a principle of thoſe mixed, combuſtible matters which they contain. *See* Chapters IV. and X.

VI. *Sulphur* is a yellowiſh ſubſtance, odorate, electric, tranſparent, and octohædral, opaque, and priſmatic, fuſible, and ſubject to two different ſorts of combuſtion. Of theſe combuſtions, one is ſlow, with a bluiſh flame, and yields ſulphureous acid; the other is rapid, with a white flame, and produces ſulphuric acid. Sulphur enters into combination with earths and alkalis; and by theſe combinations is rendered ſoluble. It unites with metals, and forms with them ſulphureous ores, which exiſt in great abundance, in the earth, and either in a ſolitary ſtate, or in combination with pure metals.

VII. *Phoſphorus* is a white ſubſtance, tranſparent, cryſtallized, lamellated, and very fuſible. It is ſubject to two different ſorts of combuſtion; burning, either ſlowly, at any known temperature, with a whitiſh flame, an acrid odour, and the formation of phoſphorous gas; or at the temperature of 167°, rapidly, with a vivid and very brilliant flame, without any ſenſible ſmell, and with the formation of phoſphoric acid. On account of its extreme combuſtibility, it is never found pure, in nature. It enters with ſufficient readineſs, into combination with ſulphur, and metals. It diſſolves in gas hydrogene; detaches the oxigene from various metallic oxides; ſeparates the metals from the acids, in the perfection of their metallic form and luſtre. It exiſts in minerals, even more abundantly than in animals, to which it was formerly ſuppoſed to be peculiar.

VIII. *Carbone*, the combuſtible matter of coals, when pure from earth, alkali, ſalts, &c. may be burnt, if ſubjected to an intenſe heat. With oxigene, it forms carbonic acid. Of all known ſubſtances, it has the ſtrongeſt attractions for oxigene; which it detaches from all other burnt bodies. It exiſts in a large proportion, in both animal and vegetable matters of all ſorts. Of vegetables, it is almoſt the only ſolid baſe; and on this account, ſtill remains in their form, after they have been decompoſed, either ſpontaneouſly, or by the action of caloric. It diſſolves in the alkalis, and in gas hydrogene. It unites with metals; forming, particularly, with iron, carbure of iron; which is found in all the kingdoms of nature, and has been improperly termed *Lead-ore*, *Plumbago*, and *Black-lead*.

IX. The metals are well known by their ponderoſity and brilliancy. They are fuſible, cryſtallizable, combuſtible. They decompoſe water and various acids, combine with ſulphur, phoſphorus, carbone, and with one another, at different temperatures. In the ſtate of oxides, they act in reſpect to the earths and alkalis, the part of acids; and again ſerve to the acids, as ſo many ſalifiable baſes. This genus differs from the preceding genera, in poſſeſſing many ſpecies. In order to give a ſhort account of theſe ſpecies, of which there are now ſeventeen, well known,—a number which will probably be much enlarged by future inveſtigation; I ſhall divide this *Genus* into five *Sections*. In the firſt ſection I ſhall comprehend metals brittle and acidifiable; which are three ſpecies; arſenic, tungſten, and molybdena. To the ſecond ſection, I refer metals that are brittle, and oxidable only; being five ſpecies; cobalt, biſmuth, nickel, manganeſe, and antimony. The third ſection will include two ſpecies of metals which are ſemi-ductile and oxidable; zinc and mercury. To the fourth ſection belong metals which are highly ductile, and eaſily oxidable; ſuch as tin, lead, iron, and copper. Laſtly, To the fifth ſection remain thoſe metals which are highly ductile, but not eaſily oxidable; and theſe are the three ſpecies of ſilver, gold, and platina. As the *ninth chapter* is entirely appropriated to the purpoſe of explaining the moſt important chemical properties of metals, it will be ſufficient here to mention briefly, ſome of the ſpecific differences by which theſe bodies are diſtinguiſhed from one another. It may be proper to obſerve, that the names of *ſemi-metals*, *imperfect metals*, *perfect metals*, having been, evidently, derived from the errors of alchemy, ought to be baniſhed from the language of a ſcience that has now attained to conſiderable accuracy.

A. *Arſenic* appears in plates of a bluiſh grey colour, brilliant, brittle, and which burn with a blue flame, and with the exhalation of a ſmell of garlic.

B. *Tungſten* is of a greyiſh white colour, granulated, friable, almoſt infuſible, almoſt inſoluble in acids, but very eaſily oxidable and acidifiable by air and caloric.

C. *Molybdena* preſents itſelf in a powder, or in blackiſh grains which are brilliant, agglutinated, brittle, ſcarcely fuſible, and which burn into a white oxide, that is volatile, priſmatic, and acidifiable.

D. *Cobalt* is granulated, fine, of a roſe-white colour, brittle and pulverizable, not eaſily fuſible, and becomes blue, when it is melted with glaſs.

E. *Biſmuth* appears in large plates of a yellowiſh white colour, brittle, very fuſible, very cryſtallizable, very oxidable.

F. *Nickel* is grey, granulated, hard, not brittle, ſcarcely fuſible, and yields a green oxide, under the action of caloric and air.

G. *Manganeſe* is of a greyiſh white colour, fine-grained, brittle, not fuſible without great difficulty; the only metal combuſtible in the open air, and which inſtantly changes its colour, and is, within a few days reduced to a black powder. To preſerve manganeſe from this ſpontaneous combuſtion, it muſt be kept in alcohol, or oil.

H. *Antimony* is white, pure, with large plates, brittle, difficult to melt; yields by combuſtion in the open air, a white oxide, which is ſublimated and cryſtallized; and which combines with the alkalis in the ſame manner as an acid.

I. *Zinc* is of a bluiſh white colour, in large plates, ſemi-brittle, not without ſome degree of malleability, eaſily fuſible, the moſt inflammable of all metals; when red-hot, it burns with a beautiful, yellowiſh white flame; it decompoſes water with great energy.

K. *Mercury* is fuſible at the temperature of 35½° below zero in Fahrenheit's thermometer; and at 38° under zero, congeals. It may be reduced to a black oxide (*æthiops per ſe*) by mere diviſion; and this ſimple proceſs extinguiſhes and fixes it in all thoſe thick or viſcid matters with which it is uſually triturated.

L. *Tin* is a gliſtering white ſubſtance, ſoft, light, ſcarcely ſonorous, ſuſceptible of being ſcratched by the nail, very fuſible, very combuſtible; which yields a white oxide that impairs the tranſparency of glaſs, and converts it into enamel.

M. *Lead* is bluiſh, duſky, ſoft, heavy, eaſily fuſible. It yields an oxide, more vitriſiable than the oxide of any other metal, and a glaſs of a topaz-yellow colour.

N. *Iron* is white, fibrous, the moſt tenacious of all metals, very averſe from fuſion, very combuſtible, the only metal attractable by the magnet. It acts with great efficacy in decompoſing water; is reduced to a powder, by expoſure to the open air; combines with charcoal, which converts it into ſteel; and is the only metal that abounds in the two organic kingdoms of nature.

O. *Copper* is of a beautiful, gliſtering red colour. It is very ſoft, very ductile, odorate, poiſonous. It burns with a green flame: its oxides are brown, blue, and green. The green oxide requires humid air to its formation.

P. *Silver* is white, pure, and brilliant, without ſmell and without taſte, highly ductile, not oxidable by caloric and air. It burns with a greeniſh flame, when acted upon by the electric ſpark. The vapours of ſulphur, blacken it. By the action of air alone, it is unalterable.

Q. *Gold* is of a beautiful, glittering yellow colour, highly ductile, leſs combuſtible and oxidable than ſilver, leſs alterable than ſilver by the contact of air. The electric ſpark reduces it to an oxide of a beautiful purple colour.

R. *Platina* is the heavieſt of all metals, of a greyiſh white colour, with little brilliancy; the moſt infuſible, the leaſt combuſtible, the leaſt alterable of all metals. It may hereafter become one of the moſt valuable inſtruments of the arts.

X. Compound combuſtible bodies are ſuch as reſult from the mutual combination of two or more of the foregoing ſimple combuſtible ſubſtances. The ſolutions of ſulphur, carbone, phoſphorus, arſenic, in gas hydrogene; are inflammable compounds. The combinations of ſulphur with phoſphorus; of carbone with iron; of metals with ſulphur, with phoſphorus, or with one another; are ſo many compound combuſtible bodies. Theſe are the combuſtible matters, the moſt common in nature. Art ſeparating them from one another, obtains them pure and ſolitary.

XI. A compariſon of the properties of compound combuſtible bodies with thoſe of the ſimple, ſhews that the former ſometimes abſorb oxigene more eagerly than their component principles would do if ſeparate; as in the inſtances of many alloys and metallic ſulphures: but that, on the other hand, ſome compound combuſtible matters are rendered more averſe from burning than their principles diſunited would be, by means of that ſtrong energy of attraction which theſe principles exert one upon another; as is the caſe with all phoſphorated metals in general. Some of theſe combuſtible compounds remain long unalterable in the air; ſeem to have in ſome manner loſt their combuſtibility, by their mutual combination; and are at laſt kindled, only by the application of a ſtrong heat to them: Of this character is carbure of iron, which has been uſefully employed to preſerve iron from ruſting.

XII. Hydrogene and carbone are united in the moſt intimate manner in the capillary tubes of vegetables. They often contain in their combination, ſmall portions of earth, alkalis, and acids, but eſpecially of oxigene. They form bitumens, oils, and reſins; which, although tending to combuſtion, and a ſeparation of their principles; yet remain for ſome time in the equilibrium of combination; until a ſudden riſe of temperature, and the contact of air or water, deſtroy the equilibrium, divide the elements of the compound, and bring them ſeparately into union with oxigene. The products of the combuſtion of thoſe compounds, are always, water and carbonic acid. The ſame thing takes place in the caſe of alcohol and æther, which are formed by modifications of the principles of vegetables, and which, in an ultimate analyſis, are found to be merely combinations of hydrogene and carbone, with more or leſs of oxigene and water. *See* Chapters X. XI. and XII.

XIII. This ſhort view of the different ſpecies of combuſtible ſubſtances, and of their principal characteriſtic properties, ſhews what an important part theſe bodies act in the phænomena of nature. It authoriſes us to divide almoſt all natural products into two great claſſes; *combuſtible* bodies, and *burnt* bodies. In the magnitude and the action of the former claſs, we ſee the cauſe of inflammable meteors, partial heats, volcanoes, perpetual changes of the ſurface of the earth, &c. In the exiſtence of the ſecond claſs, we perceive the ſource of the varieties and number of the acids, of the compound ſalts, of oxides and metallic ſalts, which diverſify in a thouſand ways the aſpect of ores in the earth; the reciprocal decompoſitions of theſe ſubſtances; and the alterations they undergo from water, air, and light. Vegetables appear to be ſo many machines organized by nature, in order to accompliſh the intimate mutual combination of many of theſe combuſtible ſubſtances; and thus to produce compounds, the unpermanency of which, makes them peculiarly ſerviceable to the grand deſigns of nature.

Application of the foregoing propoſitions.

The hiſtory of the combuſtion of every different combuſtible body, in particular detail.

The hiſtory of ſulphurated ſoils, and of native ſulphuric acid.

The phænomena of natural inflammable gaſſes in quarries, mines, the atmoſphere, &c.

The properties of terrene, alkaline, and metallic ſulphures.

The converſion of ſulphures into ſulphates and ſulphites, by the action of air and water.

The properties, extraction, and combinations of phoſphorus; metallic phoſphures.

The exiſtence of metallic carbures in nature.

The phænomena which reſpect the denſity, the gravity, the ductility, and the fuſibility of metals.

The properties and uſes of alloys.

The formation of ſecondary ores; by tranſition from native metallic ſalts.

Volcanoes; ſulphureous and bath waters.

Bitumens; the compariſon of ſulphur, charcoal, and other ſimple combuſtible bodies, with oils, &c.

CHAP. VII.

The FORMATION *and* DECOMPOSITION *of* ACIDS.

I. ALL acids reſemble one another in taſte; in their manner of giving a red colour to vegetable ſubſtances; in their common tendency to combine with earths, alkalis, and metallic oxides; and in the property of attracting and being highly attractable. It was therefore natural to conclude, as did Sir I. Newton, that they reſembled one another alſo in their intimate eſſence, and poſſeſſed ſome homogeneous principle common to them all. This truth, chemical analyſis, with the aſſiſtance of the new inventions in chemiſtry, has aſcertained beyond a doubt.

II. Since every acid contains oxigene, and loſes its acidity, in proportion as it is deprived of this principle: Acids are therefore to be regarded as burnt or oxigenated bodies, which reſemble one another by containing, all, more or leſs of the ſame acidifying element.

III. The nature of acids, may be examined in two ways; either by producing them from their elements by combuſtion, uniting oxigene with ſubſtances liable to be acidified by it; or by decompoſing, and *unburning* acidified bodies, ſo as to detach the oxigene, by means of other ſubſtances having a ſtronger affinity with it.

IV. Conſidered in this laſt point of view, all known acids may be arranged in three claſſes; 1. Acids which we can both compoſe and decompoſe, and with the nature of which we are fully acquainted: 2. Acids which we can compoſe, but not decompoſe, and with the nature of which we are, by conſequence, more imperfectly acquainted: 3. Acids which have not been, as yet, either compoſed or decompoſed, and of which the nature is, by conſequence, wholly unknown to us.

V. Of nearly thirty ſpecies of known acids, there are, ſtrictly ſpeaking, only three, of the intimate nature of which we are entirely ignorant, as having been hitherto unable either to compoſe or decompoſe them. We may, therefore, regard the character of acids in general, as being well aſcertained; and may proceed to conſider them in their general properties, and with reſpect to their compoſition.

VI. All acids are, then, compounds of *oxigene* with *ſome other body:* The *former* principle, common to them all, being the cauſe of their general reſemblance, and of thoſe qualities in which they all agree; while the *latter*, which is different in every different acid, preſents itſelf as the ſource of thoſe ſpecific qualities which are peculiar in each. The peculiar materials combined with oxigene in the various acids, are, on this account, called the *radical* or acidifiable principles.

VII. The acids are, then, all combinations, of the *radical* or acidifiable principle peculiar to each ſpecies, with oxigene, a principle common to all the ſpecies. Hence it follows, that their common properties, which give them the acid character, depend on oxigene; and that their mutually diſtinguiſhing qualities, which mark their ſpecific characters, are owing to their radical principles.

VIII. The term *Acid* denoting the eſſential, general nature of theſe ſubſtances, forms the generic name. The peculiar name of the radical principle, added to that of the genus, may ſerve to diſtinguiſh each acid in particular. Thus, ſulphur is the *radical* of the *ſulphuric* acid ; phoſphorus, of the *phoſphoric* acid ; carbone of the *carbonic* acid, &c.

IX. Although this nomenclature poſſeſs the advantage of expreſſing, with preciſion, the nature of every different acid, yet, it has not, hitherto, been applied to all the acids ; becauſe the radicals of ſome of them, are ſtill unknown ; and of others, the radicals are themſelves ſo compound, that their names could not be introduced into thoſe of the acids to which they reſpectively belong, without producing too great a multiplicity of words.

X. The acidifiable radicals may be combined with more or leſs oxigene ; and in this view, are ſuſceptible of two different ſtates of acidification. In the *one*, they are combined with the ſmalleſt portion of oxigene that is not inſufficient to render them acid ; and in this caſe, their acidity is very weak, and they act with but little energy on thoſe baſes which form with them, neutral ſalts : In the modern ſyſtematic chemical nomenclature, this ſtate of combination and acidity, is denoted by terminating the name of the weak acid in the ſyllable *ous :* Thus, we ſay the ſulphureous, the nitrous, the phoſphorus, the acetous acid, &c. The *ſecond* ſtate of acids, is that in which they contain a larger proportion of oxigene, and are for the moſt part completely ſaturated with it : They then poſſeſs all the attractive energy of which their acid nature is capable ; and this ſtate is, expreſſed in the new nomenclature, by the final ſyllable *ic*, in contradiſtinction from *ous :* Thus we ſay the ſulphuric, the nitric, the phoſphoric, the acetic acids.

XI. In regard to the proportion of oxigene combined with the acidifiable radicals, what is ſaid in the laſt ſection, may even be greatly extended in its ſignification. Every radical may be conſidered as capable of exiſting in four different ſtates : 1. As containing very little oxigene, not even enough to give it any thing of an acid nature; and in this ſtate, it is but an oxide; ſuch as ſulphur coloured red or brown by expoſure to the air; which is but an oxide of ſulphur: 2. As containing more acid, than in the former caſe, ſo much as is ſufficient to render the compound a weak acid; and ſuch is the ſulphureous acid, &c.: 3. As containing ſtill more oxigene than in the ſecond caſe, and being now ſo ſaturated, as to conſtitute a powerful acid; ſuch is the ſulphuric acid: 4. Laſtly, As containing a portion of ſuperfluous oxigene, above what is requiſite to render it a ſtrong acid; it is now called an *oxigenated*, or even a *ſuper-oxigenated acid*.

XII. From theſe foregoing facts, it appears, that there are two ways of forming acids at pleaſure, with theſe ſeveral proportions of oxigene. In *one*, we combine the radicals with the quantities of oxigene which are preciſely neceſſary to bring them into the new ſtate that we deſire to produce; as is done with ſulphur, phoſphorus, and arſenic. In the *other*, we detach from thoſe acids which contain the greateſt poſſible quantity of oxigene, certain proportions of the acidifying principle, by means of thoſe combuſtible bodies with which it moſt eagerly combines.

XIII. This laſt method depends on the attractions of oxigene for the different combuſtible bodies, and is often ſucceſsfully employed, to effect the entire decompoſition of acids, by abſtracting all the oxigene contained in them. Acids, by this means, inflame combuſtible ſubſtances. In order to this, it is only neceſſary, that the acids employed, contain no ſolid oxigene; and that the inflammable matters brought into contact with them, be able to abſorb the oxigene which thoſe acids contain, into a ſtate more ſolid than that in which it exiſts in the acids. It is not, however, every one of thoſe acids which are decompoſable by combuſtible bodies, that can heat the combuſtible matter to inflammation.

XIV. Heated charcoal is employed with ſufficient ſucceſs, to decompoſe all the acids ſuſceptible of this decompoſition.

But there are other combuſtible bodies which ſerve the ſame purpoſe. Such are moſt of the metals, phoſphorus, ſulphur, hydrogene in that dry and ſolid ſtate in which it exiſts in its vegetable compounds.

XV. All the acids owing, as has been explained, their ſpecific differences to their reſpective radical principles; they may be diſtributed into four claſſes, the diſtinctions of which ſhall be founded upon the *nature* of the radicals, as it is *known* or *unknown*, *ſimple* or *compound*.

A. The *firſt* of theſe claſſes, contains thoſe acids of which the radicals are known and ſimple; that is, which are formed of undecompoſed combuſtible ſubſtances, united with oxigene. It comprehends the following ſpecies; the ſulphuric acid, the nitric acid, the carbonic acid, the phoſphoric acid, the arſénic acid, the tunſtic acid, and the molybdic acid.

B. The *ſecond* claſs include acids having unknown radicals, but ſuch as are ſtrongly ſuſpected to be ſimple. The muriatic acid, the fluoric acid, and the boracic acid, are of this character.

C. I rank in the *third* claſs, acids of which the radicals are known to be of a binary compoſition. Such are the vegetable acids, whoſe common radical is compoſed of hydrogene and carbone. The ſuccinic acid belongs likewiſe to this claſs.

D. The *laſt* claſs conſiſts of acids, the radicals of which, are compoſed, each at leaſt of three different ſubſtances. Such are the animal acids, which have for their radicals, combinations of carbone, hydrogene, and azote.

XVI. Not only are theſe ſeveral claſſes of acids, diſtinguiſhed by general characteriſtics, marking each claſs: But even each particular acid has its peculiar properties, by which its character is diſcriminated from the characters of all other acids. Theſe properties may even be expreſſed by words and phraſes, not leſs ſimple and eaſy than thoſe which Linnæus taught naturaliſts to employ. A ſketch of this mode of expreſſing theſe properties, follows below.

XVII. The acids with ſimple and known radicals, are all decompoſable by combuſtible bodies, which they burn with more or leſs activity; and are thus reduced to their radicals. By this decompoſition was the nature of the radicals firſt diſcovered. Theſe acids may be alſo compoſed anew, by uniting oxigene with their radicals.

The acids, whoſe radicals are unknown, but from ſtrong analogies, ſuſpected to be ſimple; have no other claſſific character, but that of being indecompoſable by combuſtible bodies, and not to be formed by art.

The vegetable acids, with binary radicals, are characteriſtically diſtinguiſhed; 1. By being all decompoſable by a ſtrong heat, and by the addition of a due quantity of oxigene: 2. By affording, when they are thus decompoſed, water and carbonic acid; which are formed by the preparation of their hydrogene and carbone, and by the union of each of theſe bodies, ſeparately, with oxigene: 3. By their ſlow, ſpontaneous decompoſition, when they are diſſolved in water, and expoſed to a temperature above $54\frac{1}{2}$° F.: 4. Becauſe they cannot be decompoſed by any known combuſtible body; ſince their radical is compounded of two ſubſtances, which are remarkable, as having the ſtrongeſt poſſible attraction for oxigene: 5. Becauſe they are mutually convertible in conſequence of differing from one another, at the firſt, in nothing elſe but the proportion of their principles.

The more compound acids with three or more radicals, which derive their origin from animal matters; although the leaſt known of all the acids; have alſo ſome properties which may be regarded as their claſſific characters. Such are, the property of yielding ammoniac, when they are decompoſed by fire, and of affording Pruſſic acid by a change in the proportion of their principles.

" XVIII. To theſe claſſific characters, we ſhall next add the ſpecific characters; and ſhall here endeavour to employ a ſyſtematic, technical language, ſimilar to that of the botaniſt, and the zoologiſt.

Acids of the firſt claſs, having radicals which are ſimple and known.

A. Sulphuric acid; formed from ſulphur and oxigene, by the combuſtion of the ſulphur; inodorate, twice as heavy as water, very cauſtic, leſs volatile than water; affording ſulphureous acid gas and ſulphur, by its decompoſition with *red-hot coal*, metals, &c.; forming ſulphates with the earths, alkalis, and metallic oxides.

B. Sulphureous acid, highly odorate, very volatile, gazeous; deſtructive to blue vegetable colours, and fit to cleanſe away ſpots made with theſe colours on a white ground; abſorbing, by ſlow degrees, the oxigene from the air, and from various acids or oxides; forming ſulphites with the earthy and alkaline baſes.

C. Nitric acid, liquid, white, cauſtic, of a ſtrong nauſeous ſmell; formed of azote and oxigene; capable of inflaming ſulphur, charcoal, zinc, tin, and oils; liable to loſe, by the action of combuſtible bodies upon it, various proportions of its oxigene, and thus producing nitrous acid, nitrous gas, and nitrous oxide; deſtructive to colours; poſſeſſing the power of burning vegetable and animal ſubſtances, making them yellow, and converting them into acids; decompoſing that ammoniac which is produced by the putrefaction of animal matters; forming nitrates with the earths and alkalis; remaining in an imperfect union with metallic oxides, and having a tendency to acidify them.

D. Nitrous acid, or nitric acid with an inferior proportion of oxigene; in the form of a gas, red or orange coloured; extremely volatile, diſcolouring vegetables, becoming blue and green with water; communicating a yellow colour to nitric acid, when united with it in various proportions;

yielding nitrous gas, under the contact of combuſtible bodies; and forming nitrites with the earths and alkalis.

E. Carbonic acid is formed of carbone in the proportion of 0,28 parts, united with 0,72 of oxigene; is a gas heavier than common air, which it diſplaces; fills ſubterraneous cavities; is evolved from liquors in vinous fermentation; extinguiſhes lamps, kills animals, reddens only light blue vegetable colours; produces a precipitate of chalk in lime-water, but again diſſolves the chalk in the water; mineralizes acidulous waters; and enters into combination with barytes, lime, copper, iron, and lead in mines and quarries; forms carbonates with the earths, alkalis, and metallic oxides; is decompoſable only by phoſphorus, and when it is in union with alkaline baſes, particularly with ſoda, in the ſtate of a carbonate.

F. The phoſphoric acid is compoſed of phoſphorus and oxigene, combined by a rapid and entire combuſtion; is liquid, thick, or ſolid, vitrifiable by fire; diſſolves ſilices, while in the act of vitrification; is decompoſable by carbone, by which it is reduced to ſimple phoſphorus; and forms phoſphates with the earths, alkalis, and metallic oxides.

G. Phoſphorous acid differs from the phoſphoric, only in containing leſs oxigene; is volatile, and odorate; detaches oxigene from many other bodies; and forms phoſphites with terrene, alkaline, and metallic baſes.

H. The arſenic acid is formed of the metal called *arſenic*, in union with oxigene. Combuſtion reduces arſenic only to an oxide; and the nitric, or the oxigenated muriatic acid, is then neceſſary to afford the additional quantity of oxigene requiſite to convert the oxide into acid. The acid thus obtained, is fixed, fuſible into a glaſs, decompoſable by the action of a large quantity of light and caloric, and by many combuſtible bodies; forms arſeniates with earth, alkalis, and metallic oxides. The oxide of arſenic which combines alſo with the ſame baſes, may be regarded as a ſort of *arſenious* acid.

I. Tunſtic acid is a compound of the metal of tungſten, with oxigene; exiſts in the form of a white or yellowiſh powder, fixed, infuſible, ſcarcely ſoluble, reducible into tungſten by hydrogene, carbone, &c.; forms the native tunſtate of lime, which is called *Lapis ponderoſus*, and the native tunſtate of iron, or *wolfram* of mineralogiſts.

K. Molybdic acid is a compound of the metal named *molybdena*, with oxigene; is of a harſh taſte; is like the two acids laſt preceding, metallic; exiſts in the form of a white powder; becomes blue by the contact of thoſe bodies which reduce it; and then by the loſs of its oxigene, paſſes back into the ſtate of molybdena.

Acids of the ſecond claſs, of unknown radicals.

XIX. The acids of which the radicals are unknown, but ſuſpected to be ſimple, are three in number; the muriatic acid, the fluoric acid, and the boracic acid.

A. The muriatic acid is a gazeous or fluid ſubſtance, of a pungent ſmell, unalterable by any known combuſtible body; deprives all combuſtible bodies, particularly metallic oxides, of their oxigene, and is thus changed into *oxigenated muriatic acid*. Oxigenated muriatic acid is remarkable for its greeniſh yellow colour; its power of thickening and conſtricting the organs of animal bodies; its property of deſtroying the colours of vegetable ſubſtances, and of inflaming the moſt part of combuſtible bodies; its capacity to form with potaſh, a ſalt which rapidly kindles hot inflammable matters, and produces the pureſt vital air that is known.

B. The fluoric acid is a gazeous ſubſtance; forms in the air, a very thick white vapour; corrodes glaſs; diſſolves ſiliceous earth; and with this earth forms a permanent gas, from which water ſeparates a part of the ſilices.

C. The boracic acid is dry, cryſtallized in hexahædral plates, fuſible into a glaſs, almoſt inſipid, ſcarcely ſoluble, fuſible with ſilices, very feeble in its affinities, and liable to yield up the terrene and alkaline baſes to almoſt any other acid.

Acids of the third claſs, having binary radicals.

XX. The acids with binary radicals, mixed or compound, belong almoſt excluſively to the vegetable kingdom, and are formed by the union of carbonated hydrogene, or hydrogenated carbone, with oxigene in various proportions; which, as was before obſerved, accounts for their reciprocal converſion into one another. Theſe acids are conſiderably numerous; and their number may probably be augmented by progreſſive diſcoveries. I have therefore divided them into five genera, diſtinguiſhed from one another, by generic differences in their formation. The *firſt* of theſe genera includes thoſe pure acids which are formed in vegetables; comprehending the ſuccinic acid, which is evidently of vegetable origin: In this genus, are five ſpecies; the ſuccinic acid, the citric acid, the gallic acid, the malic acid, the benzoic acid. The *ſecond* genus contains thoſe vegetable acids, which are fully formed in vegetables, but are at the ſame time partly ſaturated with potaſh; they are called acidula; they are two ſpecies; the tartareous acidulum, and the oxalic acidulum. In the *third* genus, I rank all acids which are formed by the action of the nitric acid, and the precipitation of its oxigene, upon vegetable ſubſtances: Of this genus, we know as yet only the dſtinct ſpecies of the camphoric acid: The oxalic and malic acids indeed, are not unfrequently formed from vegetable matters, treated with nitric acid. In the *fourth* genus, I place thoſe acids which are formed in vegetables by treatment with fire; ſuch as the pyromucous, the pyro-ligneous, and the pyro-tartareous acids. The *fifth* genus conſiſts of vegetable acids produced by fermentation; of this genus we know none but the acetous ſpecies. The following are the ſpecific characters of theſe twelve acids.

A. The ſuccinic acid is diſengaged and ſublimated from heated amber; is of a ſtrong bituminous ſmell, oleaginous and inflammable, volatile, cryſtallizable into needles; forms permanent cryſtallizable ſalts, particularly with metallic oxides; and adheres more tenaciouſly to the three earths, than to the alkalis.

B. The citric acid is cryſtallizable into rhomboidal plates; is not convertible into oxalic acid by the nitric acid; has a more powerful affinity with the earths, than with the alkalis; is readily decompoſed in water, or by fire.

C. The gallic acid exiſts in abundance in nut-galls; is cryſtallized into ſmall grey or yellowiſh needles; is ſtiptic; produces a black precipitate from ſolutions of iron; reduces metallic oxides which it finds in union with other acids; is convertible into oxalic acid by the nitric acid.

D. The malic acid abounds in apples; is not cryſtallizable; is convertible into oxalic acid by the nitric acid; is formed, at the ſame time as the oxalic acid, or even more quickly, in vegetables treated with nitric acid.

E. The benzoic acid is obtained from benzoin, ſtorax, balſam of Peru, vanilla, and cinnamon, by means of heat; is cryſtallizable into flattened priſms; has an aromatic ſmell when heated; is fuſible by a gentle heat; is volatile, inflammable, ſcarcely ſoluble in water; is ſoluble, but not decompoſable by the nitric acid.

F. The tartareous acidulum, is formed of tartareous acid, imperfectly ſaturated with potaſh; exiſts in wines; is cryſtallizable, and decompoſable by fire; affords a large proportion of carbonic acid and oil, with a plentiful reſidue of carbonate of potaſh; by diſtillation, yields pyro-tartareous acid; is ſcarcely ſoluble; is decompoſable in water; forms triple ſalts with the alkalis and metallic oxides; becomes highly ſoluble upon the addition of borax or boracic acid to it. The tartareous acid obtained from this acidulum, is cryſtallizable into needles interwoven together; is unalterable in the air, is highly ſoluble, affords acidulum, upon receiving the addition of a ſmall portion of potaſh; decompoſes ſo much of ſulphate, nitrate, or muriate of potaſh, or ſoda, as may afford potaſh ſufficient to reduce the acid to acidulum; is convertible into oxalic acid by the action of the nitric acid.

G. The oxalic acidulum is formed of oxalic acid partially ſaturated with potaſh; is obtained as an extract from ſalt of ſorrel; is cryſtallized in parallelipipeds; is hardly decompoſable by fire; detaches lime from any other acid; is preciſely ſimilar to the acidulum formed by the nitric acid, when it is brought into contact with any vegetable matter whatſoever; is unalterable by the nitric acid; is the leaſt decompoſable, and the moſt oxigenated of all vegetable acids.

H. The camphoric acid is formed by the action of the nitric acid diſtilled upon camphor; is cryſtallizable in parallelipipeds; forms with earths and alkalis, neutral ſalts that are highly cryſtallizable; does not, like oxalic acid, abſtract lime from all the other acids; is very little known.

I. The pyro-tartareous acid is a modification of the tartareous acid, produced by fire; has the ſmell and colour of a burnt body; is very eaſily rarefied; and bubbles up very much, under the action of heat; is not cryſtallizable; forms with earthy and alkaline baſes, ſalts different from thoſe which the tartareous acid yields with the ſame baſes; is but little known.

K. The pyro-mucous acid is formed by the diſtillation of gums, ſugar, and fecula; has a lively agreeable odour of caramels; is volatile; colours vegetable and animal matters with a red hue; is decompoſable by intenſe heat; is but little known.

L. The pyro-ligneous acid is obtained from wood by diſtillation; has a pungent, fœtid ſmell; is not cryſtallizable; is decompoſable by a ſtrong heat; is volatile; forms peculiar ſalts with earths, alkalis, and metallic oxides; has peculiar attractions for theſe baſes; and as to its other qualities and relations, is not better known than the two ſpecies laſt preceding.

M. The acetous acid is formed by the fermentation of wine, and is on this account named *Vinegar;* has an agreeable taſte and ſmell; is liquid, volatile, and decompoſable by ardent heat; is liable to be ſuperſaturated with oxigene, when it is diſtilled with metallic oxides; and becomes in conſequence of this change acetic acid or *radical* vinegar; which is much more acrid and more odorate than the acetous acid; and is alſo inflammable, and mixed with alcohol.

Acids of the fourth claſs, with ternary radicals.

XXI. The acids whoſe radicals are ternary compounds; and which have been in general deſcribed as conſiſting of carbone, hydrogene, and azote in union with oxigene; belong chiefly to the animal kingdom. They are ſtill leſs known than thoſe of the third claſs. But, ſeeing that they all furniſh ammoniac by decompoſition with fire, and Pruſſic acid by a change in the proportion of their principles; I am led to obſerve, that that the Pruſſic acid ſeems to ſtand in the ſame relation to this genus of acids, as that of the oxalic acid to the vegetable acids in general. When animal ſubſtances are by treatment with nitric acid, converted into oxalic acid, there is conſtantly formed at the ſame time, a portion of Pruſſic acid, which is diſengaged in vapours.

There are ſeven known animal acids, which appear to belong all to this genus of compounds; namely, the lactic acid, the ſaccho-lactic acid, the ſebacic acid, the lithic acid, the formic acid, the bombic acid, and the Pruſſic acid. Each has its characteriſtic properties.

A. The lactic acid is formed by the addition of a ſmall portion of acetous acid to milk ſpontaneouſly ſoured; is not cryſtallizable; is ſoluble in alcohol; yields by diſtillation, an acid analogous to the pyro-tartareous acid; forms deliqueſcent ſalts with the terrene and alkaline baſes; decompoſes alkaline acetites.

B. The ſaccho-lactic acid is precipitated in a white powder from the oxalic acid formed by ſugar of milk and nitric acid; is almoſt inſipid, and almoſt inſoluble; is decompoſable by fire, and yields by this decompoſition, a ſublimated ſalt, having the odour of benzoin, and which forms cryſtallizable ſalts with the alkalis; is very little known.

C. The ſebacic acid is obtained from greaſe by the action of fire; is ſeparated likewiſe from greaſe by the alkalis and lime, with the help of a ſtrong heat; is liquid, white, fuming, very acrid in odour and taſte; forms cryſtallizable and fixed ſalts with earth and alkalis; decompoſes muriate of mercury; is decompoſable by a ſtrong heat.

D. The lithic acid exiſts in human urine; forms the ſtone in the bladder; is dry, cryſtallized in flat needles almoſt inſipid and inſoluble, in part volatile, decompoſable by a ſtrong heat; yields ammoniacal carbonate and Pruſſic acid when heated with fire; forms with nitric acid, a ſolution of a beautiful red colour; is ſoluble in cauſtic alkali; is precipitated from the urine of perſons under fever, with a reddiſh or greyiſh colour.

E. Formic acid is extracted from ants or *formicæ*, by diſtillation, or ſqueezing with water; reddens blue flowers of vegetables, even in the living inſect; is evolved in a ſtrongly odorate vapour; in its ſmell reſembles muſk; kills animals, in this gazeous form; is fit for the ſame domeſtic uſes as vinegar; is decompoſable by a ſtrong heat; attracts oxigene from oxigenated muriatic acid; is often ſtronger than the ſulphuric acid; forms with alkalis and earths cryſtallizable and non-deliqueſcent ſalts.

F. The bombic acid is preſerved in a reſervoir, ſituate near the anus of the chryſalis of the ſilk-worm; is extracted from this reſervoir by compreſſion, or by means of alcohol; is mingled, in the worm with a brown oil and a gum; is liquid, of an amber yellow colour, ſpontaneouſly decompoſable; yields Pruſſic acid by diſtillation, and with the nitric acid; is unknown in its combinations.

G. Pruſſic acid which ſaturates iron, and gives it the colour of Pruſſian blue, is at preſent obtained by the diſtillation of blood, by the action of the nitric acid upon the albumen, the gluten, or the fibres, &c. of animals; is evolved, while a formation of oxalic acid takes place; is remarkable for a fœtid, noxious ſmell, reſembling that of bitter almonds; is eaſily decompoſable by a great heat, and on decompoſition, yields ammoniac; is capable of aſſuming the form of gas; attracts metallic oxides from many of the other acids; may be formed by the union of hydrogene, carbone, azote, and oxigene; is ſlightly acid in its taſte; and contains, as it ſhould ſeem, but little oxigene.

XXII. From what is here laid down, it follows, that the acids which have been divided into two claſſes, as being ſimple or compound in their radicals; differ yet more eſſentially in this, that the acids of the former claſs, are not mutually convertible into one another; becauſe there is a wide difference between the properties of one ſimple radical, ſuch as ſulphur, and thoſe of another, as for inſtance phoſphorus. To effect the mutual converſion of any two acids with ſimple baſes, it would be neceſſary to begin with converting their radicals into one another; a change which art is far from knowing how to accompliſh. The ſecond claſs of acids, on the contrary, being, in general formed of a baſe compounded of hydrogene, carbone, and azote, and combined with oxigene, appear to differ from one another, only in poſſeſſing different proportions of the two or three principles in the compoſition of their radical; and in the proportion of the oxigene by which the radical is acidified. They have a tendency to experience continual variations in the proportions of their compoſition; eſpecially under the influence of change of temperature, moiſture, &c.; and they thus paſs ſpontaneouſly into different ſtates. Thus, for inſtance, by the efforts of vegetation merely, plants come to contain different acids at different periods in their growth. Thus, ſolutions of vegetable acids in water, are altered, ſuffer a change of nature, and at laſt yield all, more or leſs of carbonic acid and water, when they reach the ultimate period of their decompoſition.

XXIII. Theſe truths being clearly comprehended, we cannot fail to perceive, that there remains yet to be diſcovered, not only the nature of ſeveral acids, the compoſition of which is unknown; but even the exiſtence of perhaps a conſiderable number of new acids in plants and animals. For among the products of thoſe organized beings, of which we have begun to inveſtigate the principles, we are as yet far from having exhauſted all the poſſible combinations of carbone, hydrogene, azote, and oxigene; as a very ſlight calculation will readily ſhew. To this order of reſearches and diſcoveries, is to be referred, the examination of thoſe acids which are ſaid to exiſt in cork, in grey peaſe, and in various vegetable matters, as alſo in the clot of the blood—*cruoric acid*, and in the gaſtric juice, &c. It will alſo be perceived, upon inſpecting the particulars of the chapter immediately ſubſequent, that moſt metals, when burnt, appear to aſſume an acid character, and to act the part of acids in many combinations. Acid ſubſtances, therefore, ſeem to be the moſt numerous of all bodies, and to act the moſt important part in all thoſe chemical alterations which bodies, ſimple and compound, inceſſantly undergo.

Application of the above propoſitions.

The artificial formation of ſulphuric acid by the combuſtion of ſulphur in the great way.

The extraction of colour from white linens and ſtuffs by ſulphureous acid.

The new arts of bleaching, by the oxigenated muriatic acid.

Theory of the *Aqua Regia* of ancient chemiſts.

The art of engraving on glaſs with the fluoric acid.

Part of the theory of the formation of artificial nitre-works.

The exiſtence and formation of the known native acids.

The influence of the acids in mineralization.

The extraction and purification of vegetable acids and acidula.

The ſpontaneous formation and deſtruction of vegetable acids.

The mutual converſions of thoſe acids and acidula into one another by vegetation, fermentation, &c.

CHAP. VIII.

Of the Union of the ACIDS *with the* EARTHS *and* ALKALIS.

I. ALL the acids combine without decompoſition, with the alkaline earths, and the alkalis. Theſe combinations have been termed *neutral ſalts*, *middle ſalts*, *compound ſalts*, *ſecondary ſalts*. The two former of theſe names, are not correctly applicable to them, except when they are neither acid nor alkaline; the two latter are more accurate, and more uſeful. All theſe ſalts are eaſily formed by art. Nature exhibits a great number, eſpecially of thoſe which are formed by acids of ſimple radicals. Mineralogy is daily obtaining the knowledge of new ſalts of this character, by the analyſis of minerals, which can alone explain their intimate nature.

II. All theſe compound ſalts require to be diſtinguiſhed by two names; one expreſſing the acid; the other, the terrene or alkaline baſe. The firſt of theſe names may have two variations of termination, correſponding to two different ſtates of the acid in the compound ſalt. The termination *ate* may be employed, when the acid is one of thoſe which are completely ſaturated with oxigene, and whoſe names end in *ic*; thus the ſalts compounded with the *nitric* acid, may be called *nitrates*. Words terminating in *ite*, will ſerve to diſtinguiſh the preſence of thoſe weak acids which are not fully ſaturated with oxigene; and which when alone have names ending in *ous;* thus *nitrites* are ſalts compounded with the *nitrous* acid.

III. As there are thirty-four ſpecies of known acids, and ſeven baſes, terrene and alkaline, ſuſceptible of ſuch combination as forms compound ſalts, the number of theſe compound ſalts might be ſtated at 238. But this enumeration would be far from accurate: 1. For there are but a few acids ſuſceptible of combination with ſilices: 2. Becauſe there are other acids, which, on account of their weakneſs, cannot, without undergoing decompoſition, enter into union with terrene baſes, or with ammoniac: 3. Becauſe there are various acids capable of combining with the ſame baſes in three different ways,—or of three different ſtates of ſaturation with thoſe baſes; namely, with exceſs of acid, in the exact neutral ſtate, and with exceſs of baſe. Neither can we exactly determine the number of the terrene and alkaline compound ſalts; for we are as yet far from having examined thoſe combinations ſo fully as to know them well, and to be certain whether they may not be ſuſceptible of various ſaturations, &c.

IV. As the acids have all different elective attractions or affinities for every different terrene or alkaline baſe; it would be neceſſary for us to know all theſe different affinities, in order that we might have a complete hiſtory of the compound ſalts. But only a ſmall number of theſe affinities have hitherto been exactly determined: We are too far from poſſeſſing all the aſſemblage of facts, neceſſary to throw due light upon theſe bodies: We have not as yet thoroughly examined a tenth part of them.

V. To enter regularly upon the hiſtory of compound ſalts; we muſt divide them into genera and ſpecies, and aſcertain their genera and ſpecific characters. Of this part of the hiſtory of theſe ſalts, only a ſlight ſketch can be here given; becauſe chemiſts have hitherto paid ſmall attention to it; although it be now of the utmoſt importance, to apply the methods of botany to the enunciation of the chemical properties of theſe and other bodies.

There are two modes which may be employed for the ſyſtematic arrangement of the compound ſalts. Of theſe, one is founded upon the conſideration of the nature of the acids; the other refers to the nature of the baſes. We cannot as yet form genera which ſhall comprehend all theſe ſalts, otherwiſe than upon the nature of the acids; for the acids alone can furniſh us with generic characters; the influence of the baſes upon the properties of theſe compounds, is not yet ſo adequately known, as that we can employ theſe alkaline and terrene ſubſtances, as the heads of generic diviſions.

VI. We may reckon five and thirty genera of compound ſalts, correſponding to the number of the acids. The generic names are taken from the acids reſpectively. The following are the denominations of the thirty-five genera.

I. Genus, SULPHATES.
II. Genus, SULPHITES.
III. Genus, NITRATES.
IV. Genus, NITRITES.
V. Genus, CARBONATES.
VI. Genus, PHOSPHATES.
VII. Genus, PHOSPHITES.
VIII. Genus, ARSENIATES.
IX. Genus, ARSENITES.
X. Genus, TUNSTATES.
XI. Genus, MOLYBDATES.
XII. Genus, MURIATES.
XIII. Genus, OXIGENATED MURIATES.
XIV. Genus, FLUATES.
XV. Genus, BORATES.
XVI. Genus, SUCCINATES.
XVII. Genus, CITRATES.
XVIII. Genus, GALLATES.

XIX. Genus, MALATES.
XX. Genus, BENZOATES.
XXI. Genus, TARTRITES.
XXII. Genus, OXALITES.
XXIII. Genus, CAMPHORATES.
XXIV. Genus, PYROMUCITES.
XXV. Genus, PYROLIGNITES.
XXVI. Genus, PYRO-TARTARITES.
XXVII. Genus, ACETATES.
XXVIII. Genus, ACETITES.
XXIX. Genus, LACTATES.
XXX. Genus, SACCHO-LACTATES.
XXXI. Genus, SEBATES.
XXXII. Genus, LITHIATES.
XXXIII. Genus, FORMIATES.
XXXIV. Genus, BOMBIATES.
XXXV. Genus, PRUSSIATES.

VII. Every one of theſe five and thirty genera of compound ſalts which are here enumerated, is to be conſidered, with regard to its diſtinctive characters, or to thoſe properties which ſerve to diſtinguiſh it from every other genus, and to afford clear notions of thoſe differences by which all the genera are mutually diſcriminated. We muſt, for this end, chuſe out one ſingle property if poſſible, or at the utmoſt, two or three properties, ſtrikingly different from one another, in every genus; and thus find the peculiar characters of all the genera. The following is an attempt at this.

I. Genus, SULPHATES; decompoſable by charcoal, &c. into ſulphures.

II. Genus, SULPHITES; yield, by the contact of almoſt any acid, the ſmell of burning ſulphur with effervеſcence.

III. Genus, NITRATES; kindle combuſtible bodies, at almoſt any temperature; and are almoſt all reduced to their baſe by the action of fire.

IV. Genus, Nitrites; decompoſable by weak acids which ſeparate from them a red nitrous vapour.

V. Genus, Carbonates; in which the characters of the baſes ſtill remain more or leſs eminent; and which, with all the acids, exhibit a briſk and diſcernible effervеſcence, that proceeds till the carbonic acid be wholly diſengaged.

VI. Genus, Phosphates; decompoſable mediately or immediately, by charcoal, which ſeparates the phoſphorus.

VII. Genus, Phosphites; all immediately decompoſable by charcoal, which ſeparates the phoſphorus; and affording vapours by the contact of the ſulphuric acid, &c.

VIII. Genus, Arseniates; yield by the contact of burning coals, the odour and the white vapour of arſenic; are not decompoſable by acids alone, or without a double affinity.

IX. Genus, Arsenites; the arſenious acid is ſeparated and precipitated from their ſolutions, by the contact of any other acid,—even by that of the arſénic acid.

X. Genus, Tunstates; become yellow at the contact of the nitric or the muriatic acid.

XI. Genus, Molybdates; theſe are to be known, as yet, only by their affording molybdic acid, when treated with other acids; and by the peculiar properties of the molybdic acid.

XII. Genus, Muriates; yield muriatic acid, at the contact of the concentrated ſulphuric acid; and oxigenated muriatic acid, by the contact of nitric acid.

XIII. Genus, Oxigenated muriates; kindle all combuſtible bodies, at a lower temperature, than do nitrates, with a briſk flame; and after this combuſtion, remain in the ſtate of ſimple muriates.

XIV. Genus, Fluates; emit, at the contact of concentrated ſulphuric acid, a vapour that corrodes glaſs.

XV. Genus, Borates; fuſible, with or without the ſeparation of their baſes; yield by ſolution, in union with another acid,—boracic acid in foliated cryſtals.

XVI. Genus, Succinates; we cannot diſtinguiſh and characteriſe, without firſt decompoſing them, and obſerving their acid; they for the moſt part retain a ſmell of burnt amber.

XVII. Genus, Citrates; are not ſufficiently known to be diſcriminated by generic characters; in order to diſtinguiſh them, we muſt ſeparate the citric acid by the uſe of the ſtrongeſt mineral acids.

XVIII. Genus, Gallates; theſe are all very clearly characteriſed by the property which they poſſeſs, of producing a black precipitate from ſolutions of iron; and of effecting a partial reduction of the oxides of ſilver, gold, and mercury,—at the ſame time, when they ſeparate them from their ſolutions.

XIX. Genus, Malates; are almoſt all deliqueſcent; are to be diſtinguiſhed only by a partial extraction of their acid, by means of mineral acids.

XX. Genus, Benzoates; their genus may be determined by the ſmell which they emit of the benzoic acid; and by their affording this acid, when expoſed to the action of other more powerful acids.

XXI. Genus, Tartrites; we find characters ſufficiently ſtriking, to diſtinguiſh theſe ſalts, in their tendency to form triple ſalts, and acidula leſs ſoluble than the pure acid and the neutral ſalts which that acid forms with the ſame baſes.

XXII. Genus, Oxalates; their tendency to form acidula ſcarcely ſoluble; and the property which they poſſeſs of decompoſing all calcareous ſalts; are ſufficient to diſtinguiſh them.

XXIII. Genus, Camphorates; are too little known, for us to be able to aſſign them, generic characters; they are to be diſtinguiſhed by the preſence and the properties of the camphoric acid, partially obtained from them.

XXIV. Genus, PYROMUCITES; in the ſame caſe as the camphorates.

XXV. Genus, PYROLIGNITES; equally unknown.

XXVI. Genus, PYRO-TARTARITES; cannot be characteriſed.

XXVII. Genus, ACETATES; ſtill but indiſtinctly diſcriminated from acetites; yield, when decompoſed by mineral acids, a very ſtrong, and a very pungent white vapour.

XXVIII. Genus, ACETITES; all to be diſtinguiſhed by their acid, ſeparated from the baſe by other more powerful acids.

XXIX. Genus, LACTATES; are very little known; diſtinguiſhable only in their acid, ſeparated by other acids.

XXX. Genus, SACCHOLACTES; like the lactates, unknown.

XXXI. Genus, SEBATES; affording the white vapour, and the acrid odour of the ſebacic acid, at the contact of the more powerful mineral acids.

XXXII. Genus, LITHIATES; in their attractions, the feebleſt of all acids; decompoſable even by carbonic acid.

XXXIII. Genus, FORMIATES; very little known, and only diſtinguiſhable by their acid.

XXXIV. Genus, BOMBIATES; not better known than the formiates.

XXXV. Genus, PRUSSIATES; clearly characteriſed by their power of forming Pruſſian blue, with ſolutions of iron.

VIII. To determine the ſpecific characters of nearly 245 ſpecies which theſe thirty-five genera contain; they muſt be ſtudied with deep and aſſiduous care. In this department, the ſcience of chemiſtry, is not yet far advanced. Wanting ſuch knowledge, let us at leaſt endeavour to diſtinguiſh the path we muſt follow in order to complete the hiſtory of theſe compounds, and to fix a proper method of ſtudying their properties.

Every compound ſalt, terrene or alkaline, exhibits to the obſerver, the following particulars.

1. Form, and the varieties of form. Theſe are to be geometrically deſcribed. The inclination and the degrees of the angles; the primitive formation of the cryſtals; their interior form; their diſſection; and the laws of diminution which determine their varieties; ought to be all remarked and expreſſed.

2. Its exiſtence in nature or art; the compariſon of the native with the artificial ſalt.

3. Its taſte.

4. The action of fire upon it; which may be either nothing at all, or fuſing, vitrifying, ſublimating, decompoſing, &c.

5. The action of light.

6. The influence of air, which may be either negative, or ſuch as to furniſh or abſtract water of cryſtallization.

7. Its union with water; the quantity neceſſary to its ſolution, at different temperatures; the caloric then abſorbed or diſengaged; the cryſtallization effected by cooling or evaporation.

8. The attraction of earths, modifying, decompoſing, not affecting, or entering into a triple compound with—the ſalt.

9. The effect of the alkalis upon it, which may be negative, decompoſing, or ſometimes forming a triple compound.

10. The comparative action of the acids different from that exiſting in the compound ſalt; and this is either ſuch as to decompoſe, and deſtroy the peculiar nature of the ſalt, or ſuch as to produce no effect upon it.

11. The influence of the neutral ſalts upon it; which is either negative, or tending to form a triple ſalt by entire combination; or effecting a double decompoſition by which the baſes and acids are reciprocally changed; or producing a precipitation in conſequence of the attraction of ſome of the ſubſtances for water.

12. The ſolubility or inſolubility of the ſalt in alcohol.

13. Its alteration or inalterability by charcoal, decompoſing its acid, or leaving it unaffected.

14. The influence of vegetation and fermentation upon this ſalt.

15. Its action on the animal œconomy.

IX. If in the preſent ſtate of chemiſtry, all theſe inquiries could be ſatisfactorily anſwered; the hiſtory of the compound ſalts, terrene and alkaline, would then, not only be complete, but would throw great light on many of the phænomena of nature and art, which are, as yet, but little underſtood.

X. We are already acquainted with ſome ſaline combinations of an acid with two baſes;—and theſe baſes are more eſpecially magneſia and ammoniac. Such compounds are denominated triple *ſalts*. But, there are probably many more of them than we yet ſuſpect; and theſe demand all the attention of chemiſts. The earth expoſes both at its ſurface, and in its cavities near the ſurface, various ſaline compounds differing from thoſe which art produces,—in that the former alone exhibit the ſimultaneous exiſtence of two baſes, or even of two acids. Borate of lime, and borate of magneſia have been already found cryſtallized together in *cubic quartz*; ſulphate of lime and fluate of lime, in earth of Marmaroch, and ſtone of Eſtremadura, &c.

Application of the foregoing propoſitions.

The knowledge of native ſalts.

The cryſtallization and purification of uſeful ſalts.

The phænomena of ſolutions.

The precipitation and preparation of alumines, magneſia, &c.

The attraction of lime, potaſh, ſoda, and ammoniac for acids.

The formation of neutral ſalts in nature.

All the particular facts relative to the manufacture of ſalts.

The preparation of the nitric, muriatic, boracic, &c. acids.

CHAP. IX.

OXIDATION *and* SOLUTION *of* METALS.

I. IN the ſixth chapter preceding, we have conſidered metals as combuſtible bodies undecompounded or ſimple, and characteriſed by their more remarkable properties. But thoſe general facts are not ſufficient. The part which metals act among the phænomena of nature, and in the proceſſes of art, requires us to examine them particularly, and in ſuch detail, that we may rightly eſtimate the full extent of their varied influence.

II. Although metals be capable of mutual combination in their metallic ſtate, as well as of union with ſulphur, phoſphorus, carbone, and with all combuſtible matters in general; yet they are more commonly combined with oxigene, before entering into combination with any other ſubſtances: Or, in other words, in order to enter into moſt of the compounds in which they are known to exiſt; they muſt firſt be combined with oxigene, or reduced to the ſtate of burnt bodies. All the ſingular phænomena which the metals exhibit in their combinations; all the changes of form which they undergo; are owing to their attraction for oxigene, and to the varying proportions in which they poſſeſs this principle.

III. Although there be many caſes in which the metals are ſuſceptible of combination with oxigene; yet theſe may all be reduced to three general heads. The firſt is *the contact of air*, aſſiſted by the action of caloric; the ſecond is owing to the *decompoſition of water*; the third, to the *decompoſition of acids*. In this threefold point of view, we ſhall here conſider the oxidation and ſolution of metals.

IV. All metals heated in the air, and raiſed to a certain temperature, higher or lower, before or after their fuſion, are liable to burn with a briſk flame, an ardent heat, and a real deflagration. They then abſorb oxigene in a more or leſs ſolid ſtate. Such as are oxidated ſlowly, and without any ſenſible inflammation, nevertheleſs diſengage light and caloric from vital air; but in quantities ſo ſmall, that the light and caloric do not, during their diſengagement, become perceptible to our organs.

V. Riſe of temperature favours the abſorption of oxigene from the atmoſphere, by metals; and renders the combination of this principle with theſe combuſtible bodies, more ſolid than it would otherwiſe be.

VI. While ſome metals burn in the air, only at a very high temperature,—ſuch as gold, ſilver, and platina; there are others that burn at any temperature, even at the loweſt and with the utmoſt readineſs; ſuch as manganeſe which is oxidated, and crumbles down into a powder, in the ſpace of a few hours, by the contact of air merely, and this even ſeveral degrees under zero. Some metals, ſuch as iron, copper, lead, &c. burn ſlowly, and in the courſe of a few months in the air, even cold.

VII. All metals increaſe in weight during this proceſs, which never takes place without the acceſs of air; and abſorb a new principle of oxigene from the atmoſphere, without loſing any thing of their former ſubſtance. The name of *calcination* formerly given to this phænomenon, cannot now be retained, any more than the term *metallic calces*. The words *combuſtion*, and *oxidation*, are now employed to expreſs this proceſs; as is the phraſe *metallic oxides*, to diſtinguiſh metals which are burnt in it.

VIII. The colours which metals exhibit, as they burn, or with which their flame is tinged, appear to owe their origin to the ſolution of metallic particles in the light that is diſengaged: thus copper affords a green flame, &c.

IX. Not only do all metals, compared with one another, in their combuſtion by the contact of air, abſorb different quantities of oxigene, in order to their ſaturation; but likewiſe each metal conſidered by itſelf, abſorbs various proportions, and ſtops at different points of oxidation, according as the degrees of its temperature vary. Thus tin, lead, copper, iron, change their colour, and are ſtudded with the tints of the rainbow, at the loweſt degrees of heat to which they are expoſed in contact with air: lead firſt becomes a grey oxide, then a yellow, and at laſt a red oxide; mercury paſſes from black to white, from white to yellow, from yellow to red; iron at firſt a black oxide, becomes next a green, then a brown, and at laſt a white oxide; copper is firſt a brown oxide, then a blue, and in its laſt degree of oxidation, takes a green colour.

X. The metals differ all from one another, in their attractions for oxigene. There are ſome, which light, almoſt alone, and with very little caloric, is able to deprive of their oxigene, ſuch as gold, ſilver, &c. Others require in order to ſeparate the oxigene, a great degree of heat, and much light; ſuch as mercury. Laſtly, moſt metallic oxides do not yield their oxigene to caloric and light alone, and unaſſiſted by other matters. To decompoſe theſe laſt oxides, they are heated with charcoal which deprives them of their oxigene.

XI. In conſequence likewiſe of this diverſity in the attractions of the metals for oxigene, ſome metals will abſtract the oxigene from the oxides of other metals; almoſt any other metal detaches oxigene from gold or ſilver; copper detaches it from mercury, iron from copper, &c. Theſe attractions are not, as yet, all well known. What we do know of them, indicates the following to be the order of the attractions of theſe ſeveral metals for oxigene; beginning with that which is the ſtrongeſt; mangaueſe, zinc, iron, tin, copper, mercury, ſilver, gold.

XII. Several metals decompoſe water; and accompliſh this ſo much the more ſenſibly or rapidly in proportion as their temperature is higher; becauſe then the great quantity of the caloric employed, more powerfully attracts and diſſolves the hydrogene. Thus fire decompoſes water with great energy, at a white-red heat; but cannot effect the ſame decompoſition otherwiſe than very ſlowly at even the higheſt temperature of the atmoſphere.

XIII. Iron, zinc, tin, antimony appear to be capable of decompoſing water. Probably, manganeſe, and even ſome other metallic ſubſtances are equally capable of accompliſhing the ſame effects. This decompoſition is owing to an attraction in the metal for oxigene, ſtronger than that of oxigene for hydrogene; and in conſequence, the oxides of thoſe metals which do not decompoſe water, are liable to be wholly decompoſed by hydrogene. But here we muſt diſtinguiſh among the different degrees of oxidation: for oxide of iron highly oxidated, namely to a brown colour, is partly decompoſed by hydrogene, and reſtored to the ſtate of a black oxide; as iron abſtracts oxigene from water only till it be oxidated black: Beyond this ſtate of oxidation, iron is unable to decompoſe water.

XIV. All metals capable of decompoſing water, effect this decompoſition much more eaſily and entirely, when they are aided by the contact of a body that has a great tendency to combine with their oxides. It often happens, even that metals, like other combuſtible bodies, which would not alone decompoſe water, become capable of effecting this decompoſition, in conſequence of the preſence of ſome other ſubſtances, which act by a diſpoſing affinity. Thus the preſence of acids, renders almoſt all metals capable of effecting the decompoſition of water.

XV. Metallic oxides have this peculiar in their combinations, that they ſeem to perform the functions of alkalis or of terrene and alkaline baſes, in reſpect to the acids; although they be, on the other hand, capable of combining with earths and alkalis, as if they were acids. There are indeed fewer of thoſe oxides that incline to act the part of acids, than of thoſe which are fitter for baſes to compound ſalts; and it is obſerved, in general, that the oxides to which oxigene adheres the moſt tenaciouſly, are thoſe which ſaturate alkalis in the manner of acids;—ſuch as the oxides of antimony, lead, iron, and manganeſe. It has been already related in the VI. chapter, that there are three metals actually acidifiable.

XVI. The metals cannot be diſſolved by the acids, without being previouſly oxidated. On this account, metallic oxides ſoluble in acids, diſſolve in them ſlowly and without efferveſcence: but metals are not ſoluble in the ſame menſtrua, without movement and efferveſcence.

XVII. The efferveſcence produced by the ſolution of metals, is owing to this cauſe, that when they abſorb the oxigene, they detach it from a principle which then aſſumes the form of a gas or elaſtic fluid. This principle proceeds either from water or acids, according as the one or the other of theſe is the ſubſtance decompoſed. Sometimes it originates from both theſe bodies at once; and then they are both decompoſed by the metal together.

XVIII. The ſulphuric acid thus decompoſed by metals, if it be concentrated, yields ſulphureous gas: Nitric acid, upon the ſame occaſion yields nitrous gas.

XIX. The ſulphuric acid, diluted in water, greatly promoting the decompoſition of the water by metals, yields, in this caſe, gas hydrogene. Solutions of zinc and iron in the aqueous ſulphuric acid, act chiefly in this way. The phoſphoric acid exhibits with metals, nearly the ſame phænomena, as the ſulphuric acid.

XX. The nitric acid is not only decompoſed by various metals, but even ſuffers the water in which it is diluted to be decompoſed at the ſame time as itſelf. In order to this it is enough, that the metal diſſolved in the acid, be extremely greedy of oxigene, as is tin. The hydrogene of the water, in this caſe, combining with the azote of the nitric acid, forms ammoniac; and hence theſe ſolutions afford no gas, but are found to contain ammoniacal nitrate. From this it may be underſtood, how moſt ſolutions of white metals in nitric acid, come to afford vapours of ammoniac, when quicklime is caſt into them.

XXI. The muriatic acid not being ſuſceptible of decompoſition by combuſtible bodies, can by itſelf diſſolve, but few metallic ſubſtances. It acts only on thoſe metals which are ſo greedy of oxigene, as to decompoſe the water in which it is diluted. While metals are diſſolved by the muriatic acid, there is always a conſiderable quantity of hydrogenous gas diſengaged.

XXII. Not only is the muriatic acid unſuſceptible of decompoſition by the metals; but it poſſeſſes likewiſe the property of abſorbing oxigene from almoſt all metallic oxides. It paſſes upon this into the ſtate of oxigenated muriatic acid. To its attraction for oxigene does this metal owe the property it poſſeſſes of diſſolving metallic oxides with facility: and it is on this account employed ſucceſsfully to diſſolve oxide of iron on which the other acids do not act. If metallic oxides ſuperſaturated with oxigene be diſſolved in muriatic acid, the acid effervesces; a part of it then paſſing into the ſtate of oxigenated muriatic acid gas. If theſe oxides be oxigenated only to that degree which is requiſite for their combination with the acid, they will then diſſolve without emotion, and without effervescence, as ſalt or ſugar in water.

XXIII. The boracic and fluoric acids combine but weakly with metallic oxides. They are incapable of diſſolving pure metals, becauſe they are not decompoſable by theſe bodies. Yet with water, they produce the oxidation of thoſe metals which have the ſtrongeſt affinity for oxigene. The ſame is the caſe with the carbonic acid, which combines readily with moſt metallic oxides, and in nature is often found in union with them.

XXIV. The metallic acids are eaſily decompoſed by the moſt combuſtible of the metals. They combine readily with the oxides; and in nature, are often found thus combined.

XXV. The vegetable and animal acids, which have radicals compoſed of hydrogene and carbone, are not decompoſed by the metals, but render water highly decompoſable by theſe bodies; and combine in a ſtate of ſufficient ſolidity, with the metallic oxides. Several of them, reduce theſe oxides to the ſtate of metals.

XXVI. The metallic oxides cannot oombine with acids, or remain in union with them, unleſs in conſequence of containing certain determinate proportions of oxigene. Under theſe proportions, the combination cannot take place; if the due proportions be exceeded, the ſubſtances combined, cannot remain in union.

XXVII. Beſide this general truth; there is another of the ſame order, which relates to each metal and each acid in particular. And this is, that the acid and metal cannot remain in union, otherwiſe than within the often ſtraitened limits of oxidation. There is a determinate proportion of oxigene in the combination of an acid with a metallic oxide.

XXVIII. It is in virtue of this law, that metallic ſolutions expoſed to the air, yield a precipitate, and become turbid, in proportion as the metallic oxide abſorbing oxigene from the atmoſphere, becomes gradually inſoluble in the acid. This is the ratio of thoſe decompoſitions which are accompliſhed by the atmoſphere, upon moſt metallic ſulphates and nitrates.

XXIX. Nay it often happens, that metallic oxides diſſolved in acids, gradually re-act upon theſe ſalts, and abſtract from them, even in cloſe veſſels, and in contact with air, a portion of their oxigene, ſo that the oxide is ſoon ſeparated from the acid, and is precipitated to the bottom of the ſolution.

XXX. Heat is ſingularly favourable to this ſucceſſive decompoſition of acids by metallic oxides. Thus nitric ſolutions become turbid, or more and more decompoſable, by the action of air and water, if they be at the ſame time heated. This is particularly remarkable in the caſe of the nitric ſolution of mercury.

XXXI. Some metals have ſo great a tendency to oxidation by acids, that they can neither remain in union with them, nor yet form permanent ſolutions. Such are, particularly thoſe which poſſeſs the property of becoming acid or forming oxides ſuſceptible of combination with alkalis; arſenic, tungſten, molybdena, antimony, tin, iron, &c. Solutions of theſe metals, in nitric acid eſpecially, are always charged with precipitates, and contain little or no metallic oxide.

XXXII. From theſe facts it appears, that, in order to form metallic ſalts, the metallic oxides muſt remain permanently in union with the acids, without having any tendency to ſeparation. It is alſo neceſſary, that care be taken not to augment their affinity for oxigene; and to avoid bringing this principle into contact with them.

XXXIII. Compound metallic ſalts always, or almoſt always, poſſeſs an exceſs of acid. They are otherwiſe, all more or leſs acrid and corroſive; which ſhews that almoſt all metallic oxides have a tendency to become acid.

XXXIV. Thoſe properties of metallic ſalts which it is of conſequence for us to know, may be reduced under the following heads. 1. Form and its varieties; 2. Taſte and cauſticity, more or leſs conſiderable; 3. Alteration by light;

4. Fuſion, deſiccation, decompoſition more or leſs perfect, by caloric; 5. Deliqueſcence, efflorеſcence, or decompoſition, more or leſs entire, by means of air; 6. Solubility in water, hot or cold, decompoſition more or leſs thorough, by pure water, &c.; 7. Decompoſition by alkalis and earths, the nature of precipitated metallic oxides, the complete precipitation or formation of triple ſalts, partly alkaline or terrene, and in part metallic; 8. The alteration of precipitated metallic oxides at the moment of their precipitation, either by air, or by the nature of the alkali employed, as in the caſe of ammoniac; 9. Reciprocal alteration by different acids, decompoſition or the contrary, attraction of acids by metallic oxides, the changes of oxides which are diſtinguiſhable by their colours; 10. Alteration by the neutral ſalts, terrene or alkaline, which exhibit either an union without decompoſition, or a double decompoſition; 11. The reciprocal action of metallic ſalts upon one another, which diſplays either a ſimple union, or a ſimple change of baſes by the acids, or a change in the combination of the oxigene by which the two oxides are precipitated;—the one partially *de-oxidated;* the other *ſuper-oxidated;*—and ſuch for inſtance, is that uſeful precipitation of the muriatic ſolution of gold by the muriatic ſolution of tin, which furniſhes the *purple precipitate of Caſſius;* 12. Union with the terrene or alkaline ſulphures, and the formation of the different ſorts of ſulphureous ores.

XXXV. Metallic oxides differ from one another in the degrees of their affinity with acids; ſo that ſome of them may be employed to decompoſe the combinations of others. But above all, the varying affinities of the metals with oxigene, act as the principal cauſe of the phænomena of the precipitation of metallic ſolutions: Thus different metals, while they take away the oxigene from other metals diſſolved in acids, cauſe theſe laſt, to appear again in the metallic form; as copper, for inſtance, does with mercury, mercury with ſilver, iron with copper, zinc with iron, &c. Sometimes the metals do not detach all the oxigene from the metallic oxides diſſolved in the acids. This happens when the precipitating metals do not require all the oxigene of the metals in ſolution. Thus tin, when precipitating oxide of gold, does not abſorb all the oxigene which that oxide contained, but ſuffers the gold to be precipitated in a particular ſtate of oxidation. Metallic oxides when they thus ſhare the oxigene between them in new proportions, are precipitated with properties that deſerve to be better obſerved, than they have hitherto been.

Application of the general facts in this chapter.

Preparation of all the metallic oxides uſed in the arts.
Coloured glaſſes, enamels.
Metallic ſalts uſeful in the arts.
Effects of theſe ſalts in the arts in which they are employed.
Solutions, and partings of metals.
Precipitation of metallic oxides by earths and alkalis.

Theſe applications are in general ſo various and ſo uſeful, that they cannot be explained in detail, elſewhere than under the particular hiſtory of each different metal.

CHAP. X.

FORMATION *and* NATURE *of* VEGETABLE MATTERS.

I. THOSE matters which compoſe the texture of vegetables, differ from mineral ſubſtances, in being of an order of compoſition which is more complex, and in being all highly ſuſceptible of decompoſition or analyſis, while none of them is ſuſceptible of ſyntheſis.

II. Only the ſubſtantial contexture of living vegetables, only their vegetative organs—can form thoſe matters which are extracted from them; no inſtrument of art is capable of imitating thoſe compoſitions that are continually effected in the organized frames of plants.

III. Although it be with four or five natural ſubſtances, caloric, light, water, air, and carbone, extracted from the remains of plants, which have been crumbled down and blended in the ſoil; that vegetables elaborate all the materials of which their contexture is formed; yet, do we find a wonderful variety of properties in theſe materials. We may, however reduce all theſe properties to a certain number of heads, under the name of *the immediate principles of plants;* becauſe theſe principles are obtained by ſimple proceſſes, almoſt entirely ly mechanical, and by a ſort of immediate analyſis that produces no alteration of their nature.

IV. Theſe matters, being more or leſs compound, are lodged in particular organs, or in diſtinct veſſels or cells, &c. Sometimes their ſeat is in the root or in the ſtem, in the bark and the leaves all together: At other times, on the contrary, only the flowers, fruits, or ſeeds, and even ſome particular parts of theſe organs, contain the immediate principles. This varying ſituation of theſe immediate principles, ſhews the differences in the organization of the texture to be the cauſe of that diverſity of nature which each of theſe matters diſplays.

V. The different place occupied by each of the different materials of vegetables, is often ſuch as to permit us eaſily to obtain them pure and ſeparate. Where ſuch a diſtribution takes place, it is ſufficient to bruiſe or open the veſſels or cells containing the immediate principles, to open them, or to ſqueeze out the liquid juices. Nature, by the ſole force of vegetation, often preſents this ſeparation already effected, on the outſide of plants. Thus manna, gum, reſins, &c. flow ſpontaneouſly. Art is often obliged to ſeparate ſome of theſe materials from the confuſion in which they are mingled and united with various other matters. The means ſhe employs for this, are uſually ſimple, and eaſily practiſed; ſuch as reſt, filtration, preſſure, waſhing, diſtillation by a gentle heat, none of which, alters the ſubſtances ſubjected to it.

VI. Among the materials which compoſe the frame of vegetable bodies; which are obtained from them by ſimple means that alter not their nature; and which are either fluid or ſolid; may be reckoned the following ſubſtances.

1. The extractive matter, or extract.
2. The mucous matter, or mucilage,
3. Sugar.
4. Eſſential ſalts.

5. Fixed oil.
6. Volatile oil.
7. Aroma.
8. Camphor.
9. Reſin.
10. Balſam.
11. Gum reſin.
12. Feculum.
13. Gluten.
14. Colouring matter.
15. Gum elaſtic.
16. The ligneous part.

Beſide theſe ſixteen principles, there is found in the analyſis of vegetables, a ſubſtance reſembling the albumen in the animal kingdom. It is probable that there are ſeveral other vegetable principles ſtill unknown; ſuch as the matter which ſerves for tanning hides, &c.

VII. It is proper, that the reader here fully underſtand, that, when all the facts in the analyſis of vegetables, have been reduced to general terms or leading reſults; there has been nothing more found in any of all the plants hitherto examined, but the foregoing eighteen ſubſtances. Theſe actually compoſe the contexture and fabric of all known vegetables; and when theſe are ſeparated from any vegetable, that vegetable is very accurately analyſed. Yet, we are not to ſuppoſe, that theſe eighteen immediate materials exiſt in all the different parts of vegetables, or even in every different vegetable. Some plants, out of all their parts, afford not even ſo many as five or ſix of theſe materials; others contain eight or nine of them; ſome yield them all. But, ſuppoſing, that we could mix together, and confound, even chemically, all thoſe plants which are ſubjected to any chemical proceſſes; the mixture, however ſeemingly various, would not exhibit more than the ſixteen or eighteen ſubſtances above enumerated, as the reſults of the moſt exact and elaborate analyſis. Vegetables may therefore be ſaid to be formed of thoſe immediate materials.

VIII. Each of the materials above mentioned, poſſeſſes peculiar diſtinctive properties, from among which we muſt ſelect thoſe which may the beſt mark their different characters, and diſcriminate them, one from another. It is not impoſſible to handle this ſubject in the manner of the botaniſts; uſing but one characteriſtic or ſpecific phraſe, to diſtinguiſh each of the materials of which we ſpeak. Although this method have not as yet been either propoſed or executed in chemiſtry; we ſhall endeavour to give a ſketch of it in the ſubſequent ſections; as has been already done in the caſe of the acids, and the compound ſalts.

Characters of the immediate materials of vegetables.

IX. *Extractive matter* or *extract*, is a dry, brown matter, ſomewhat deliqueſcent, ſoluble in water; is obtained from the inſpiſſated juices of vegetables, from infuſions, and from decoctions evaporated; yields by diſtillation, an acid, a little ammoniac, and ſome oil; abſorbs oxigene from the atmoſphere, and becomes gradually inſoluble, in conſequence of this abſorption; is erroneouſly regarded as a natural ſoap; is compounded of carbone, hydrogene, azote, and oxigene, and has always a tendency to abſorb more of this laſt principle, than it contained in its primitive ſtate.

X. *Mucous matter* or *mucilage*, is a glutinous, viſcid, inſipid ſubſtance, which yields pyro-mucous acid by diſtillation; is ſoluble in water cold or hot; does not abſorb oxigene from the atmoſphere; becomes dry and brittle in the form of gum; exiſts in the roots, the young twigs, and the leaves; is obtained by expreſſion from the bark of trees; connects their fibres together as they grow.

XI. *Sugar*, is of an agreeable, pungent taſte, cryſtallizable, ſoluble, fermentible, in all reſpects very like to mucilage, but differing in its ſuſceptibility of fermentation, and forming alcohol. Mucilage and ſugar are both compounds of carbone, hydrogene, and oxigene; and they differ from extract; 1. In having a ſmaller proportion of hydrogene;—in conſequence of which, they do not, like extract, abſorb oxigene from the atmoſphere: 2. In being deſtitute of azote, owing to which, they yield no ammoniac by diſtillation.

XII. *Eſſential ſalt*, comprehends the vegetable acids which are in general formed of hydrogene and carbone more copiouſly oxigenated than in the three foregoing ingredients: and in conſequence of this, the addition of oxigene to thoſe ingredients, converts them into acids. The vegetable acids, in whatever number they may be, appear to differ from one another in nothing, ſave the proportions of their three principles. They are all decompoſable by fire, and ſuſceptible of mutual converſion into one another; and in an ultimate analyſis, they are all reducible upon the addition of oxigene, to water and carbnic acid. (*See* title VII.)

XIII. *Fixed oil*, was formerly named *fat oil;* is thick, mild, inodorous; burns when volatilized; forms ſoaps with the cauſtic alkalis; is mixed with a mucilage which Scheele calls the *mild principle of oils;* is thickened and concreted by the contact of air, and the abſorption of oxigene; ſuffers the ſame effects from acids and metallic oxides; is compounded of carbone, hydrogene, and a ſmall proportion of oxigene. It differs from the preceding compounds, in poſſeſſing a larger proportion of hydrogene. Hence its combuſtibility, and tendency to change into water and carbonic acid, when it is burnt with a ſufficient quantity of air; as in matches which are hollow, and ſurrounded on all ſides with air; forming lamps with an interior current of air.

XIV. *Volatile oil*, called alſo *eſſential oil, and eſſence*, is acrid, highly odorate, wholly reducible to vapour at the heat of 212° F.; does not readily combine with alkalis; is inflammable by acids; is inſpiſſated by oxigene to a reſin; burns more rapidly than fixed oil, and affords more water; ſuffers an eaſier precipitation of its charcoal, which then forms lamp-black.

XV. *Aroma*, otherwiſe called *ſpiritus rector*, is a very volatile principle, reducible to vapour by the heat of the atmoſphere, and forming a peculiar atmoſphere around plants; diſtillation of the plant on a *balneum mariæ*, affords the aroma together with water; ſometimes aroma is of an inflammable nature; it preſents in other inſtances, ſaline properties; it combines with alcohol, fixed oils, vinegar, &c. and in theſe combinations, forms what in pharmacy is called *diſtilled waters;* it contributes by its preſence to the quantity of volatile oils, that is obtained from plants, and has ſo great a reſemblance to theſe oils, that the one has been often miſtaken for the other. The intimate nature of aroma is not yet exactly known. We begin to think, that it may be a peculiar ſubſtance, a ſolitary principle diſengaged from vegetable matters; while theſe matters themſelves are at the ſame time, entirely reduced to vapour.

XVI. *Camphor*, is a matter now known to exiſt in many vegetables; is to be reckoned one of their immediate principles; is of a concrete and cryſtalline form, highly volatile, combuſtible with ſmoke, ſoluble in a great quantity of water, in alcohol, and in æther; exiſts in many volatile oils; is contained, in purity, in the trunk and leaves of a ſort of laurel from which it is ordinarily obtained; is very little known, as to its intimate nature; forms with nitric acid, a new and peculiar acid.

XVII. *Reſin*, is a matter, ſoft or dry, ſcarcely odorate, combuſtible, ſoluble in alcohol, but not in water; ſcarcely alterable by acids; hardly ſuſceptible of union with alkalis; is obtained from an inſpiſſated volatile oil, from which it ſeems to differ only in poſſeſſing a larger proportion of oxigene.

XVIII. *Balſam*, is reſin combined with benzoic acid, more highly odorate than pure reſin; is deprived of its concrete acid by the action of fire and water; yields this acid to earths and alkalis; becomes after the loſs of the acid, not unlike to reſin.

XIX. *Gum-reſin*, is a concrete juice, partly ſoluble in water; forms with water, a ſort of emulſion as well as with vinegar, which has been ſuppoſed to be its univerſal ſolvent; is more ſoluble in alcohol; does not flow naturally, like reſin, from vegetables, but is obtained from their veſſels bruiſed, in the form of a white or variouſly coloured juice, of a fœtid odour, more or leſs reſembling that of garlic.

XX. *Feculum*, is a pulverulent, dry, white, inſipid, combuſtible matter; yields by diſtillation, a large proportion of pyro-mucous acid; is ſoluble in boiling water; forms with this liquid, a jelly; is convertible into oxalic and malic acid by the action of the nitric acid; exiſts in all the white and brittle matters of vegetables, particularly in tuberculous roots, and in the grains of gramineous plants; forms the baſis of the nouriſhment of animals; and is diſpoſed to become with ſufficient rapidity, a component principle of their bodies.

XXI. *Gluten*, is a ſubſtance, elaſtic, ductile, ſeemingly fibrous or membraneous, inſoluble in water, ſlightly ſoluble in alcohol; yields by diſtillation a large proportion of ammoniac; is putrefiable like an animal ſubſtance; takes like animal ſubſtances, a yellow colour, upon the contact of nitric acid; is convertible by nitric acid into oxalic acid; and exiſting particularly in the flour of wheat, forms the difference between this and flour of other grains, by giving to the former, the property of compoſing a paſte.

XXII. *Colouring matter*, goes always along with the one or the other of the preceding materials; appears to vary in its nature,—being ſometimes ſoluble in water, and ſometimes ſubject only to the action of alkalis, oils, or alcohol;

owes its diverſified properties to different quantities of oxigene fixed in it; has an affinity for combination with alumines, oxide of tin, &c. is capable of more or leſs perfect combination with the contexture of bodies animal and vegetable.

XXIII. *Gum-elaſtic,* reſembles gum-reſin; appears to exiſt in many vegetables; is remarkable for the ductility and elaſticity which it retains, when dry; affords ammoniac by diſtillation; diffuſes a fœtid odour when burnt; exiſts at firſt in the form of a white, lacteous fluid, and paſſes into the ſtate of gum elaſtic by abſorbing oxigene from the atmoſphere.

XXIV. *The ligneous part,* or *wood,* a matter that has been hitherto too much neglected by chemiſts, forms the ſolid baſe of all vegetables; but is by much more copious in thoſe which are hard, than in ſuch as are ſoft; has been erroneouſly regarded as an earth; is inſoluble in water; affords by diſtillation that particular acid which is called pyro-ligneous; contains a great quantity of carbone; paſſes into three or four different acid ſtates, by the action of nitric acid; appears to be the laſt product of vegetation.

XXV. From what has been above explained concerning the immediate and known materials of vegetables, it follows; that they are all reducible in a laſt analyſis, to three or four principles, the principles, the primary components of them all; namely, hydrogene, carbone, oxigene, and in ſeveral of the above materials azote; and that thoſe materials differ from one another only in the diverſity of the proportions in which they ſeverally contain the elementary conſtituents. But, if by ſimple calculation, we endeavour to find the number of different compounds that may reſult from ſuch combinations, in all the poſſible proportions of three or four primary principles, we ſhall find, that a much greater number of them may eaſily exiſt. Yet, as every one of the ternary or quaternary compoſitions which form the immediate materials of vegetables, admits, as it ſhould ſeem, a certain latitude in the proportions of its principles with which it will ſtill retain its general character of extractive, mucous, oil, acid, reſin, &c. &c.; it is natural to infer, that the various proportions of the elementary principles, comprehended within thoſe latitudes, muſt determine the vaſt, unmeaſurable variety of colour, ſmell, taſte, and conſiſtency, which is well known to diſtinguiſh all the materials of vegetables; and which is univerſally obſerved in the component parts of thoſe vegetable matters which are in common uſe for human food, clothing, buildings, &c.

XXVI. Upon the ſame conſideration, it will be eaſily conceived, that vegetables muſt differ in the nature and ſpecific properties of their materials, according to the different periods in the advancement of their vegetation; that they can never remain long in the ſame ſtate; and that the diverſified ſcenes which the periods of germination, foliation, bloſſoming, fructification, and maturation, the ſucceſſive æras of vegetable life, exhibit, muſt neceſſarily be accompanied and diſcriminated by internal changes, correſponding to the variation of external appearances. Taſte in all its varieties of modification, ſmell which is no leſs variable, and thoſe diverſities of contexture and conſiſtency which diſtinguiſh the different periods in the progreſs of vegetation, are ſo many inconteſtible proofs of this.

XXVII. It is a new advantage derived from the improvements of modern chemiſtry; that we are now enabled to diſcern the nature of the materials of plants, which is more complex than that of mineral ſubſtances. This acquired knowledge leads us to an eſtimate of the changes which vegetable matters ſuffer from different chemical agents. We can no longer ſay that we are ignorant of the manner in which the deſtructive agency of fire operates upon vegetable ſubſtances. From the conſiderations here ſtated, it appears, that when a vegetable, either entire or in its ſeparate products, is ſubmitted to the action of fire; the caloric tends to reduce thoſe complex compounds to compounds of a more ſimple character, by combining their principles, by two and two, in proportions widely different from thoſe in which they before exiſted together. By heating vegetable products gently, we diſengage the hydrogene which burns alone, and leaves a large reſidue of carbone; when they are ſtrongly heated, the carbone is diſengaged together with the hydrogene; both burn together in the air; and the only reſidue left, is a ſmall portion of earth and ſalts forming vegetable aſhes.

XXVIII. All the immediate principles of vegetables, are then reducible in an ultimate analyſis, to three or four primary principles, namely, hydrogene, carbone, oxigene, and a little azote in ſome of them: This analyſis correſponds accurately to the manner in which vegetables are nouriſhed, grow, ſpread out, and preſerve their exiſtence; ſince we know that nothing but thoſe ſimple principles is required to ſupport vegetation:—We have therefore nothing farther to inveſtigate, but the manner in which plants appropriate to themſelves theſe elements, and the means by which they combine by their organic functions;—in order to enable us to form by compoſitions, thoſe ſubſtances of which the properties have been explained.

XXIX. There ſeems to be no doubt but that water affords the hydrogene of vegetables; that they decompoſe water in their leaves, aided by the contact of ſolar light; that they abſorb the hydrogene of the decompoſition, which is fixed in them, in the ſtate of oil, or extract, or mucilage, &c.; and that they evolve the oxigene, of which a great part is fuſed by light and caloric, and diſengaged into the ſtate of vital air. But, a portion of the oxigene of the water thus decompoſed, is at the ſame time fixed in the contexture of the vegetable, and is retained there, particularly by the attraction of the carbone.

XXX. It is not ſo eaſy to give an account of the origin of the carbone which exiſts in vegetables. Some naturaliſts think that vegetables decompoſe carbonic acid at the ſame time as water, and abſorb the carbone. This aſſertion is without proof; although it has gained new authority ſince the diſcovery of the decompoſition by phoſphorus of the carbonic acid combined with ſoda. Other chemiſts think, that vegetable earth, *humus*, dunghills, and eſpecially water from dunghills afford carbone divided, or even diſſolved in water; that plants abſorb this principle by their roots, and do not abſtract it from carbonic acid. According to this opinion, dung affords nothing but carbone; and the water of the dunghill is but a ſaturated ſolution of this principle. To theſe data muſt the chemical theory of vegetation be confined, until it ſhall be enlarged by farther inveſtigation and experiment.

Application of the general truths in the tenth chapter.

Theſe general truths are applicable to a very great variety of caſes in nature and the arts. They reſpect agriculture, rural œconomy, pharmacy, materia medica, and all thoſe arts which are employed upon vegetable ſubſtances. The following are a few of the moſt important caſes of their application.

Germination.
The unfolding of the leaves of vegetables,
The bloſſoming of vegetables.
Fructification.
The ripening of fruits and grains.
The ſucceſſive formation of gum, extract, oil, reſin, ſalts, ſugar, colouring matter, wood, in the different periods of the life of a plant.
The growth of the ligneous ſubſtance, of the bark, &c.

Pharmaceutical preparations of juices, extracts, eſſential ſalts, mucilages, oils, reſins, gum-reſins, aromatic waters, &c.

The arts of the ſugar-boiler, the confectioner, the miller, the baker, the ſtarch-maker, the vine-dreſſer, the brewer, the diſtiller, the varniſher, the dyer, the paper-maker, the indigo-maker, the colour-man, the flax-dreſſer, the oil-man, the ſoap-boiler, the perfumer, the charcoal-burner, &c.

CHAP. XI.

Of the FORMATION *and the* NATURE *of* ANIMAL SUBSTANCES; THEORY *of* ANIMALIZATION.

IT is a certain truth, that animals cannot ſupport their exiſtence, without the uſe of vegetables. In natural hiſtory, it has long been ſaid, that vegetables are formed from minerals, animals from vegetables. But if this truth have been long known; yet the manner in which theſe bodies are mutually changed one into another, remains ſtill unaſcertained. This however is the grand ſubject upon which, above all others, the labours of the chemiſt ought to be employed. This problem once ſolved, we ſhall obtain an exact knowledge of every thing reſpecting the animal œconomy. Modern diſcoveries afford already a variety of reſults which muſt be uſeful in theſe important reſearches.

II. The ſureſt means for reſolving this problem, is undoubtedly, firſt, to diſcriminate accurately between the different animal ſubſtances; to compare them with the peculiar matters of the vegetable kingdom; and carefully to examine the difference or reſemblance ſubſiſting between the two claſſes. There is no doubt, but that, if theſe differences were once well known; we might then diſcover the cauſes to which they are owing.

III. Collecting the reſults of all the analyſes that have been lately made of the blood and humours, and of the ſolid parts of the human body which are evidently formed by the concretion of the fluids; we ſhall find the moſt ſtriking differences between animal and vegetable ſubſtances, to be the following.

A. The property in animal ſubſtances of affording ammoniac and fœtid products, when acted upon by fire.

B. Their property of putrefying more eaſily, and more rapidly, and of emiting an odour much more noiſome.

C. Their yielding much more of gas azote, when acted upon by nitric acid.

D. Their contributing in a ſingular manner to the formation of nitric acid.

IV. All theſe differences ſeem to depend upon the exiſtence of a particular principle which is azote, in much greater abundance in animal than in vegetable bodies. It ſhould ſeem then, that the addition of azote to vegetables, might fully aſſimilate their nature to that of animal matters.

V. It is however to be farther obſerved, that to theſe primary and *capital diſtinctions* between animal and vegetable ſubſtances, there are other particular phænomena to be added; the influence of which, although, no doubt ſmaller upon the animal compound; is yet, not to be neglected. Such, among others, is the preſence of the phoſphoric acid, and of different phoſphates, particularly phoſphates of ſoda, lime, and ammoniac, in animal humours. To theſe ſalts is owing the peculiar quality, and the almoſt incombuſtible character of the coal of animal matters.

VI. That particular principle which is ſo copious in theſe ſubſtances, and which eſpecially eſtabliſhes the grand diſtinction between them and vegetable ſubſtances, namely, azote, appears therefore to be the efficient cauſe of the properties by which animal matters are diſtinguiſhed; and particularly of that ſort of concreſcibility or elaſticity, of which we ſhall ſoon have occaſion to ſpeak more at length. It may be affirmed therefore, that if animal matters be deprived of their azote, they may be reduced in ſome meaſure, to the character of vegetables; and that to convert vegetables into animal ſubſtances, it will be ſufficient to introduce into them, or combine with them a due quantity of azote.

VII. We may conſider all matters forming the bodies of animals as ſo many immediate principles; juſt as we repreſented the materials of vegetables. And each of thoſe immediate principles of animal bodies may be characteriſed by the expoſition of its moſt eminent properties. By thus examining and diſtinguiſhing blood, milk, bile, fat, urine, &c. as well as the ſolids of animals; and by deſcribing them with that brevity which we have exhibited in the foregoing chapter; we ſhall form a ſort of comparative ſcale that will indicate thoſe reſemblances and differences which we wiſh to know.

VIII. *The blood* is a red fluid; hot at the temperature of 104° F. in man, in quadrupeds, and in birds,—and in oviparous quadrupeds, ſerpents, and fiſhes, at the mean temperature of the places of their habitation; concreſcible by cold, miſcible with water; ſeparates almoſt ſpontaneouſly into three different ſubſtances, *white ſerum*, *red ſerum*, or the colouring part, and *fibrous matter*; exhibits in each of theſe matters diſtinctive characters,—in the white ſerum, an alkaline nature, and owing to the intimate combination of oxigene in it, a diſpoſition to coagulate by fire, metallic oxides, &c.—in the red ſerum, the ſame general nature, differing from the white ſerum only in having oxide of iron preſent in it,—in the fibrous matter, or *fibrina*, ſpontaneous concreſcibility, and ſolubility in alkalis. Theſe principal characters are to be conſidered as belonging to the whole blood, which ſeems to be the primary principle of all other animal ſubſtances, and the common ſource of all the humours, and all the ſolids. It has been called *fluid fleſh*, on account of the *fibrina* which is concreted by cooling. The cauſe of its heat has been aſcertained to exiſt in the alteration and abſorption of vital air by reſpiration. The renovation of the blood by the chyle, and the change of the chyle into animal matter, have alſo appeared to be owing to the diſengagement of a great quantity of carbone and hydrogene in the lungs.

IX. *Milk*, is a white fluid, mild and ſaccharine, formed of ſerum, cheeſe, and butter intermingled; and repreſenting a genuine animal emulſion. In the ſerum of milk, there is to be particularly obſerved, that matter which is called *ſugar of milk*, and has the character of a ſort of incipient ſugar. Another thing particularly worthy of careful notice, in milk, in the quantity of phoſphate of lime, much larger than in any of the other humours, which is found in it; and which ſeems to indicate, that it has been the intention of Nature, to place in the firſt nutriment deſigned for animals, a large quantity of that oſſeous baſe which is neceſſary for the formation and growth of the bones in the firſt ſtage of life. Cheeſe is ſimply albuminous matter. Butter is a concrete oil, the ſolidity of which, and its eaſy ſeparation from milk by motion only, appear to be owing to the abſorption of oxigene from the atmoſphere during the formation of the cream.

X. *Bile* is an oily, ſaponaceous juice, compounded of an oil nearly in the ſtate of the white of the whale, and of ſoda united with this oil, and theſe mixed with the albuminous liquid formed in the liver, which viſcus itſelf contains a great quantity of oil. Every thing in the ſyſtem of this bulky gland, concurs to diſcover a diſpoſition, an organization deſtined by Nature to ſeparate from the blood, that great exceſs of fat which is produced by the ſlow circulation of this fluid through the venous ſyſtem of the lower region of the belly. This conſideration which muſt hereafter form one of the principal baſes of chemical phyſiology, accounts for the bulk of the liver in a fœtus in which reſpiration has not yet commenced, and in thoſe animals which have not reſpiratory organs,

gans, ſuch as man, birds, and quadrupeds have. It likewiſe explains the origin of ſome diſeaſes of the liver, particularly of biliary ſtones or concretions.

XI. The *greaſe* or *fat*, is a ſort of oleaginous matter formed at the extremities of the arteries, at the fartheſt poſſible diſtance from the centre of animal heat and motion; forms a ſort of reſervoir, in which that large quantity of hydrogene is fixed, which the lungs are unable to evacuate; is an oil combined with a conſiderable proportion of oxigene, and containing, beſides, ſebacic acid. To conſider fat in this light, is, a point ſingularly ſtriking in the chemical phyſiology of animals.

XII. *Urine* is an excrementitious fluid, more or leſs coloured, acrid and ſaline, remarkable for the great quantity of uncombined phoſphoric acid, of phoſphate of ſoda, of ammoniac and lime which it contains; ſtill more remarkable for containing a peculiar acid which has not as yet been found in the reſt of the animal humours; and which is now named *lithic acid;* becauſe it forms the baſe of calculi in the reins or bladder, in the diſeaſe called *lithiaſis*.

Some of the moſt valuable diſcoveries of chemiſtry reſpect the urine; medicine has ſtill diſcoveries to make concerning this excrementitious fluid. Conſidering it, in the firſt inſtance, as a lixivium intended by Nature, to convey out of the body, a great quantity of ſaline matters which would otherwiſe prove noxious to the vital functions: we are hence led to perceive, in the next place, that, in the urinous evacuation, the proportion of the principles will vary with the ſtate of the body, and thus will become a ſort of meaſure indicating by its varying modifications, the health or ſickneſs of the vital frame. Phyſicians have already ſucceſsfully begun their obſervations upon this matter. The urine is to be regarded as containing always the matter of concretions in the reins or bladder. Theſe concretions require to their formation, nothing but the detention of this matter, a longer time than

Nature has deſigned, in its proper organs, on an incipient nodule on which ſucceſſive concretions may be from time to time depoſited. The proportions of the different principles in urine, and eſpecially the naked acids which it contains, are alſo to be carefully obſerved; as is likewiſe the phoſphate of lime ſuſpended in it; both which vary ſtrangely in diſeaſes of the joints, of the aponeuroſes, and of the bones. Of theſe facts accurately noted, ſkilful obſervers may hereafter make a happy uſe in medicine; deriving from them, new means of knowing the nature of ſuch diſtempers, of aſcertaining their progreſs, and perhaps of accompliſhing their cure.

XIII. We can ſay little concerning the other animal fluids, ſuch as the humour that is tranſpired from the pores, ſweat, the gaſtric juice, the cerumen of the ears, the ſaliva, the humour of tears, the mucus of the noſe, the ſeminal fluid, &c. becauſe all theſe fluids have hitherto been but little examined. They have, every one, no doubt, a particular compoſition, different in each of them, from all the reſt, in various points, eſpecially in the proportion of their principles. Some of theſe principles being ſomewhat better known by modern experiments, than the reſt, exhibit a combination of a particular mucilage with water, pure ſoda, phoſphate of lime, and phoſphate of ſoda. Such are tears, the mucus of the noſe, and the ſpermatic juice. Of theſe, the two former poſſeſs the property of becoming thick by the contact of air, and the abſorption of oxigene; which probably conſtitutes the maturity of the humours in the brain and lungs in caſes of catarrh. The ſeminal fluid exhibits the ſingular phænomenon of the cryſtallization of phoſphate of lime, hitherto unknown in other inſtances.

XIV. Conſidering the whole of thoſe ſolid matters which compoſe the varied contexture of the different organs of animals; we may divide the ſubſtances that form them into three principal genera. The firſt of theſe will comprehend the albumen; the ſecond the gluten, or gelatinous matter;

the third, the fibrina or fibrous matter. Of theſe bodies two have already been noticed in the VIII. ſection of this chapter, under the article, *Blood.* We ſhall here briefly mention thoſe permanent phænomena which are to be conſidered as the characters of each of the genera.

FIRST GENUS.

Albumen is concreſcible by heat, by acids, by oxides, and in general by oxigene whenever it is concrete or nearly concrete; is ſoluble by alkalis; exiſts, more or leſs condenſed or oxigenated, and wrought into conſiſtency, in the membranes, the tendons, the griſtles, and in general, in all white animal matters.

SECOND GENUS.

The *gluten*, partakes of the ſolidity of the former genus in moſt of the white organs; is ſuſceptible of eaſy ſeparation and ſolution by boiling water, to which when cooled, it gives the form of a jelly. As it forms the baſe, or the larger proportion in all the white organs in general; theſe are ſuſceptible of more or leſs perfect ſolution in boiling water, and form tranſparent jellies by the refrigeration of their ſolutions.

THIRD GENUS.

The *fibrina* is inſoluble in water at any temperature; is ſoluble in acids; contains a large proportion of azote; is condenſed, concreted, and organized in muſcular fleſh, which may be regarded as the reſervoir of all the fibrina contained in the blood. Conſidering the muſcles as the ſecretory organs of this fibrous matter of the blood; we may examine and obſerve all the modifications of the quantity or proportion in which it is fixed in thoſe organs; and may attend particularly to that excluſion of it, which they ſeem to exact in certain morbific ſtates of the body, in old age, &c.

XV. Theſe three matters, albumen, gluten, and fibrina, in concretions, in combinations of two and two, or three and three together, eſpecially if they be in different proportions, compoſe all the ſolids of animal bodies. They are ſeparated from one another by an eaſy and ſimple analyſis. They form alſo various animal fluids, particularly albumen. Only, in theſe fluids, they contain leſs oxigene, more water, and are united with acids, neutral ſalts, &c. It is to be obſerved, that the gluten is as ſcanty in the fluids, as it is copious in the ſolids: and ſeems therefore to owe its gelatinous nature to that elaboration which it undergoes, when paſſing from a fluid to a ſolid ſtate. Albumen artificially diſſolved by acids, aſſumes properties analogous to thoſe of the gluten.

XVI. The ſolid, oſſeous ſubſtance of animals, is of another order of compoſition. A large quantity of an almoſt inſoluble terrene ſalt (phoſphate of lime) is depoſited in the primitive contexture or parenchyma of the bones. This is the whole myſtery of the ſtructure and compoſition of theſe organs. In conſequence of this, bones afford a jelly by decoction in water, and yield by diſtillation, a large proportion of oil and ammoniac. Bones once well calcined or burnt, are after this, nothing more than calcareous phoſphate, mixed with ſome portions of carbonate, muriate, and phoſphate of ſoda.

XVII. When theſe preceding animal matters, eſpecially when the white fluids inſpiſſated, or the white organs, are heated with nitric acid; there is diſengaged from them, a quantity, greater or ſmaller, of gas azote, and of Pruſſic acid gas; which appears to be nothing elſe than a combination of azote, hydrogene, and carbone, with a ſmall proportion of oxigene. Of this product, the gluten yields the leaſt; the albumen, more; the fibrina, the moſt. In proportion as this new combination of the principles of animal matters, takes place by means of the nitric acid; thoſe matters ſeem to return to their original ſtate of vegetable ſubſtances; from which, as has been obſerved, they differ materially in nothing but in poſſeſſing a quantity of azote, in having different proportions of carbone and hydrogene; and in the greater complexity of the number of the combined materials into which the primary elements are formed in the animal compound. Inſtead of being ternary compounds, as vegetables are, animal matters are quaternary compounds, or even more complex. Azote is the fourth primary principle of animal matters, which they poſſeſs in addition to the hydrogene, carbone, and oxigene of vegetables.

XVIII. Thus the converſion of vegetable matters into animal matters, which conſiſts merely in the fixation or addition of azote; is to be conſidered as the principal phænomenon of animalization. This alone explains the principal difficulties of that phænomenon: and when the mechaniſm provided for the addition of this azote ſhall have become ſufficiently known; moſt of the functions of the animal œconomy, which contribute to, or depend upon it, will then alſo be known.

XIX. What is already known concerning this laſt ſubject, is limited to the following particulars. It is not ſo much by the addition of a new quantity, as by the removal of other principles in conſequence of which the proportion of the azote originally preſent, becomes greater, that this phænomenon is accompliſhed. In reſpiration, the blood exhales a great quantity of hydrogene and carbone; the laſt either ſimply diſſolved in gas hydrogene, or elſe reduced to carbonic acid in the very act of circulation, and in the vaſcular ſyſtem, as ſome modern phyſiologiſts have conceived. In the cavities of the *bronchiæ* during the act of reſpiration, and by means of this act, the hydrogene forms water which is exhaled in expiration. A portion of the oxigene appears to be at the ſame time fixed in the blood in the lungs; and circulating with this fluid through the veſſels, it is gradually combined with the carbone, ſo as to form that carbonic acid which is diſengaged from the venous blood in the breaſt. It is eaſily conceived, that a large quantity of hydrogene and carbone being thus diſengaged by reſpiration, the proportion of the azote muſt be by the ſame act increaſed. The inveſtigation of the mechaniſm of the other

functions,

functions, will no doubt lead to new diſcoveries more important than theſe which are here detailed. What has been done within theſe laſt few years, naturally leads us to expect, that much more may within no long time be done. The analogy of action which has been diſcovered to ſubſiſt between digeſtion, reſpiration, the circulation, and tranſpiration, has begun to eſtabliſh upon new views much more ſolid than thoſe which were formerly entertained,—a ſyſtem of animal phyſiology that promiſes a rich harveſt of diſcoveries and utilities. No doubt, by the aſſiduous inveſtigation of the phænomena of digeſtion and of growth in young animals, we ſhall at length ſucceed ſo far as to erect upon thoſe baſes, a ſtructure equally new and ſolid. Every thing is ready for this grand ſeries of reſearches: Several philoſophers have already entered upon it: A new ardour ſpringing from the new conceptions which they have formed, ſtimulates and encourages thoſe who are engaged in this department of phyſics. The path which they have opened up, cannot fail to conduct them to reſults the moſt preciſe and accurate; exceeding in theſe qualities, all that has been hitherto advanced concerning the functions which conſtitute animal life.

Application of theſe propoſitions.

The functions of the animal œconomy; and particularly,
Reſpiration;
Digeſtion;
Hematoſis, or the formation of blood;
Tranſpiration;
The ſecretion of the bile;
Oſſification and oſteogony;
Nutrition;
Maladies ariſing from the corruption of the humours, &c.
Animal concretions;

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The action of various medicines upon the humours, &c.;

Thoſe arts which are employed in the treatment of animal matters; particularly, the arts of the tanner, the currier, the maker of glues, the maker of whipcords; the arts of extracting oils, and of manufacturing into uſeful implements, the horns, bones, hooves, &c. of animals.

CHAP. XII.

Of the Spontaneous Destruction *of* Animal *and* Vegetable Matters.

I. WHEN vegetables and animals are deprived of liſe, or when their products are abſtracted from the individuals to which they belonged; movements are then excited in them, which deſtroy their contexture, and alter their compoſition. Theſe movements form different ſorts of fermentations. The purpoſe of Nature in exciting them, is evidently to render more ſimple, thoſe compounds which are formed by vegetation and animalization; ſo that they may enter readily into new combinations of different kinds. That matter which has been for a time employed in forming the bodies of vegetables and animals, is, after their functions are ended, to paſs through other combinations, and to enter into the compoſition of other bodies.

II. From this definition of fermentation in general, it appears, that the ſpecies of fermentation muſt be as various as thoſe of the animal and vegetable ſubſtances that are affected by it. But, of theſe, a number paſs through the ſame proceſs, while they are reduced to greater ſimplicity of compoſition; and in reference to this, all the variety of fermentations may be reduced to three leading ſpecies; vinous fermentation, acetous fermentation, putrid fermentation.

III. Vinous fermentation, as its name indicates, is that fermentation which produces wine or alcohol. The only matter ſubject to it, is ſaccharine matter, diluted in a certain quantity of water, and mixed with ſome third matter, vegetable or animal, extract, ſalt, feculum, &c.; for it is now certain, that ſugar and water alone are not ſuſceptible of vinous fermentation. The ſaccharine ſubſtance is ſo copious, and ſo univerſally diffuſed through all vegetable and even animal matters; that there is a prodigious number of bodies capable of affording wine or forming alcohol. All ſweet and ſaccharine fruits when reduced to a pulp, and particularly their expreſſed juices, undergo an internal emotion at a temperature not under 66° F. if they be at the ſame time, in a large quantity, and neither too thick, nor too liquid. Hence that vaſt quantity of different wines which we poſſeſs; reckoning with them, the decoctions of germinating grains, in which the ſaccharine part is developed by germination; and even the vinous liquors made with milk, honey, blood, &c.

IV. Vinous fermentation diſcovers itſelf in ſaccharine juices, by an increaſe of their bulk, the formation of a copious froth that covers their ſurface, riſe of temperature, the diſengagement of a great deal of carbonic acid, the converſion of a ſweet liquor into an acid, hot, and pungent fluid.

V. The cauſe of this fermentation appears to depend on the decompoſition of water, of whoſe oxigene, a large ſhare is brought into union with the carbone of the ſugar, which it burns, and ſo converts it into carbonic acid. At the ſame time, the hydrogene of the water, is brought into contact with the decarbonated ſugar, and by combination with it, forms alcohol. Alcohol may be defined to be *ſugar, deprived of a portion of its carbone, the place of which is ſupplied by a certain proportion of hydrogene.* This theory explains both the formation of the carbonic acid which is diſengaged during vinous fermentation; and the formation of alcohol, with all the properties of this new product.

VI. Pure alcohol is a white liquid, of a ſtrong ſmell, of an hot and acrid taſte, convertible into vapour at the temperature of 176° F. inflammable at any temperature; affords, when burning, a large proportion of water and carbonic acid; diffuſes no ſmoke during its combuſtion; is miſcible in any proportion with water, expelling the air and a portion of caloric, while the combiuation takes place; diſſolves the pure or cauſtic alkalis; decompoſes the acids, and by this decompoſition, is itſelf converted into æther; diſſolves deliqueſcent neutral ſalts, and many metallic ſalts; detaches from vegetables their volatile oil, aroma, reſin, balſam, a part of their gum-reſin, and ſeveral colouring matters; is by means of all its properties, uſeful in many operations of the arts.

VII. The formation of alcohol is effected by the deſtruction of a principle of vegetables; the ſaccharine matter ſuffering upon this occaſion, a decompoſition by which it is reduced to greater ſimplicity. Vinous or alcoholic fermentation is therefore a commencement of the deſtruction of thoſe principles which are formed by vegetation. It may be conſidered as an interior emotion, deſigned by Nature, to ſimplify the order of compoſition which vegetable ſubſtances exhibit.

VIII. Acid or acetous fermentation is the ſecond natural movement by which vegetable compounds are reduced to a more ſimple ſtate of compoſition. This fermentation which produces vinegar, can take place only in liquors that have already undergone vinous fermentation. It has been remarked that the contact of air is neceſſary for the production of vinegar. We have even ſeen air to be abſorbed by wine turning ſour; and it appears, that a certain proportion of oxigene from the atmoſphere is neceſſary to the formation of acetous acid.

IX. There, are no doubt, other ſorts of fermentation analogous to that by which vinegar is formed; but of ſuch fermentations the products are not yet well known. Such, for inſtance, is that which takes place in water mixed with ſtarch, which is called the ſtarch-maker's ſour water. Such likewiſe is that of ſoured bread, ſoured cabbages, and ſour liquors. All theſe changes are to be conſidered as modes of decompoſition which ſerve to ſimplify the complicated combinations of vegetables.

X. Laſtly, After that the liquids of vegetables, or their ſolids moiſtened, have paſſed into the acid ſtate; their decompoſition continuing under favourable circumſtances; that is to ſay, in a mild or hot temperature, expoſed to the air, or in contact with water; conducts them to a putrefaction by which they are in the end volatilized, in the form of gas, as to moſt of their principles. There is diſengaged, water, carbonic acid, carbonated gas hydrogene, ſulphurated gas hydrogene, volatile oil in vapour, and ſometimes, even gas azote, and ammoniac. Nothing remains, after this, but a brown or black reſidue, known by the name of *mould,* conſiſting of carbone that is ſomewhat fat and oily, and from which water extracts ſeveral ſaline ſubſtances, and a ſmall portion of extractive matter.

XI. Nature, when organizing animals, and forming their humours and ſolids by complex compoſitions; has mingled in their compoſition a germ of deſtruction, which unfolds itſelf after the death of the individual.

This deſtruction is effected by that movement which is called *putrefaction.* It conſiſts in a ſort of fermentation, in a ſlow decompoſition of thoſe liquid or ſolid ſubſtances in which it takes place. The order of the compoſition of animal matters is more complex than that of vegetables, and renders them much more ſuſceptible of putrid decompoſition.

XII. Animal matters being compounded of hydrogene, carbone, oxigene, and azote; and having often ſuperadded to theſe principles, portions of ſulphur, phoſphorus, &c.; when they are deprived of that motion and continual renovation which conſtitute animal life; are ſoon altered by the more ſimple mutual attractions of their principles, which tend to combine together, by two and two. This re-action produces binary compounds, ſuch as carbonic acid, nitric acid, ammoniac, carbonated gas hydrogene; which are by degrees evolved into the atmoſphere; and as they are evolved, proportionally diminiſh the bulk of the animal matters from which they are ſeparated. It is in this manner, and in conſequence of natural decompoſition; that animal matters are ſeen to become ſoft, to change their colour and ſmell, to loſe their ſtructure and form, to diffuſe through the atmoſphere, vapours and gaſſes which are there diſſolved, and are deſtined to convey into other bodies, particularly into vegetables, the materials neceſſary to their formation.

XIII. All the phænomena of the putrefaction of animal matters, depend upon the mechaniſm which has been explained. The union of hydrogene and azote produces ammoniac, which has been regarded as the principal product of putrefaction. The combination of carbone with oxigene accounts for the formation and diſengagement of carbonic acid, in which all the myſteries of putrefaction were ſuppoſed to conſiſt, about the time of the firſt diſcovery of the gaſſes. The nitric acid, to the formation of which, animal matters powerfully contribute in artificial nitre-works,—is produced by the union of azote with oxigene. A certain quantity of gas hydrogene is diſengaged, and involves with it ſome portions of carbone, ſulphur, and even phoſphorus. Hence that noiſome ſmell, which is ſo exceedingly various, and hence, perhaps, the phoſphoreſcence of all putrefying animal ſubſtances.

XIV. When all theſe volatile principles are combined two and two together, and diſperſed through the atmoſphere, there remains no reſidue, but a portion of carbone, united or mixed with fixed ſaline ſubſtances, ſuch as phoſphate of ſoda, and phoſphate of lime. Theſe reſidues form a ſort of *mould* that is called *animal earth*; which often retains in it a little ſulphurated and carbonated hydrogenous gas, a little fat, and ſome extract; and in which vegetables find abundance of thoſe

principles

principles which are fit for the formation of their materials. Hence is it that this animal reſidue, when the previous putrefaction is entirely paſt, forms an excellent ſpecies of manure.

XV. There is a certain quantity of water neceſſary to this putrid decompoſition of animal matters. It affords the oxigene requiſite to the compoſition of the carbonic acid and nitric acid. It contributes remarkably to excite the putrefactive emotions, by means of the attractions of its oxigene. The hydrogene, too, evolved from the water, muſt doubtleſs contribute greatly to the formation of the ammoniac: for it is a well known fact, that, when animal matters are diluted in a large quantity of water, they afford abundance of ammoniac, during their decompoſition.

XVI. Putrefaction, conſiſting in a ſeries of peculiar attractions, is modified in many different ways by all its exterior circumſtances, ſuch as temperature, the medium in which animal matters are placed, the ſtate of the atmoſphere, as more or leſs ponderous, dry or humid, &c. It is thus that carcaſes buried in the earth, immerſed in water, or ſuſpended in air, undergo a diverſity of changes to which their maſs, their quantity, and the vicinity of other bodies, as well as all the varied properties of the three media here mentioned, continually give new and different forms.

XVII. Proofs of the truth of this aſſertion, occur in what happens to dead bodies, interred either ſeparately, each by itſelf,—or in heaps together. The former being ſurrounded by a great quantity of earth, are ſoon deſtroyed by putrefaction, the æriform or liquid products of which are abſorbed by the ſurrounding earth, or by the atmoſphere. Bodies buried in heaps together, not having around them the ſame ſort of earthen or atmoſpheric receiver, remain long undeſtroyed; their animal matter is entirely converted into ammoniac and concrete oil: and this oil with the volatile alkali, forms that ſaponaceous matter which has been found in the earth of burying grounds, in which there has been too great a number of corpſes depoſited.

XVIII. In water, different phænomena attend the deſtruction of animal matters: As faſt as the new products are formed, the water diſſolves, and conveys them into the air. A continued moiſture at a temperature, a few degrees above 32° F. favours the putrefaction of theſe matters, and their ſolution into gas. A dry, hot air, on the contrary, volatilizing the water, dries and hardens the animal bodies, almoſt as well as the dry burning ſand does in Egypt, that land of mummies.

XIX. Although all the circumſtances of putrefaction, and all the varieties, almoſt innumerable, of the phænomena which they exhibit; have not been as yet either diſcovered or deſcribed; it is however acknowledged, that all thoſe phænomena muſt be limited to the converſion of the more complex compounds into others of a ſimpler compoſition; which Nature then employs in new combinations forming the materials of other complex bodies. She had only lent them for a time to animals and vegetables. She carries on a perpetual circulation of compoſitions and decompoſitions; which *diſplay* her power, and evince her fecundity, at the ſame time while they ſhew a plan of action, equally grand and ſimple in its operations.

Application of the propoſitions in this laſt chapter.

Beſide all the objects mentioned at the end of the two chapters immediately foregoing, to which the articles in this chapter afford almoſt direct applications; the principles particularly explained in this chapter, are likewiſe ſuſceptible of theſe following applications.

The preſervation of all ſubſtances extracted from vegetables;

The different ſpontaneous alterations which vegetables undergo; acetous fermentation, vinous fermentation, &c.;

The products of theſe alterations, often employed in the arts;
The production of ammoniac and nitric acid;
The influence of putrefaction in the different regions of living bodies;
The infection, and other evils, produced by the vapours of putrefied matters;
The theory of the ſituation and management of hoſpitals, drains, ſinks, lay-ſtalls, common-ſewers, cemeteries, &c.

THE PHILOSOPHY

OF

CHEMISTRY.

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ADVERTISEMENT.

ADVERTISEMENT.

SOON after entering upon the ſtudy of chemiſtry, I was induced, by the perſuaſion of a Bookſeller, to undertake a tranſlation of FOURCROY'S ELEMENTS OF CHEMISTRY, from the *third edition* of the original work, then newly publiſhed. In that edition, the author had, for the firſt time, adopted the *opinions* and the *language* of the NEW THEORY, which had been lately ſuggeſted by the important diſcoveries of the illuſtrious and lamented Lavoiſier. The new language of that theory was in the tranſlation, to be accommodated to the ſtructure and analogy of the Engliſh tongue; and other peculiar difficulties alſo concurred, to render the taſk in which I had engaged, extremely arduous. I acquitted myſelf of it, as well as I could. My tranſlation has been called for, ſold, and read; till the edition then printed, has been exhauſted; and till a *fourth Edition* of the *Original Work*, with *alterations* and *additions* by the *Author*, has been received in this country.

I, in the mean time, continued to purſue my chemical ſtudies, with that fondneſs, which the ſublimity of the general truths of this ſcience, the endleſs diverſity of the phenomena that fall under its laws, and its unrivalled utility for enlightening the arts of life, are well adapted to excite in every ingenuous mind. With great pleaſure, therefore, did I liſten to the requeſt of the preſent Publiſhers, when they informed me of their intention to reprint my tranſlation of Fourcroy's work; and deſired that I would reviſe and correct it for the preſs; collating it with the new edition of the *original*; altering what the author had altered; and adding whatever additions he ſhould appear to have made. I was pleaſed to have a new opportunity preſented to me, of humbly doing ſomewhat more to promote the knowledge of a ſcience in which I delighted. I was not leſs pleaſed with the opportunity of correcting ſome *erroneous numbers*, ſome *awkward expreſſions*, ſome unneceſſarily *paraphraſtic paſſages*, and *others* in which an *attempt to concentrate* the meaning of the author, had *produced obſcurity*, in that tranſlation of this excellent ſyſtem of chemiſtry, which I was now to reviſe and improve.

What I thus again undertook, I have executed; and the work is here preſented to the public. I have carefully reviſed my former tranſlation, and have corrected whatever I found to be inaccurate, obſcure, or coarſely inelegant in it. I have collated it with the new edition of the original work, and have adopted all the alterations and additions of the author. I have even added a conſiderable number of *Notes*, correcting errors, illuſtrating obſcurities, or ſupplying deficiencies of important information, in FOURCROY's text.

Theſe NOTES it had been eaſy for me to enlarge to almoſt any indefinite bulk and number. But, I reflected, that notes, however they may variegate the pages of a book, are too often overlooked, in the reading, eſpecially by the young ſtudent; or, if peruſed, ſerve too often for no other purpoſe in the peruſal, except to diſtract the attention of the reader, and to interrupt to his mind the author's chain of reaſoning or narration. After reading an elementary treatiſe, exhibiting rather the whole ſyſtem of the general principles of any ſcience, than all the detail of minute facts comprehended under thoſe principles; let the ſtudent no longer plod among compilations, but trace the ſcience which he ſtudies, through the writings of thoſe authors alone, who have enriched it with original and uncontroverted theories, or with new obſervations and experiments. It were perhaps deſireable, that even this elaborate and comprehenſive work of FOURCROY, ſhould be condenſed to one half of its preſent bulk, rather than clogged and burthened with endleſs additions. I have given ſuch a proportion of *notes* as ſeemed indiſpenſibly requiſite; but none for the ſake of uſeleſs oſtentation.

I have always thought that the phyſical ſciences ought not to reject the advantages of purity, perſpicuity, and preciſion of ſtyle, any more than the moral ſciences and the fine arts. It is piteous to ſee, what a Babyloniſh jargon the tranſlation of many books of chemiſtry, natural hiſtory, and natural philoſophy, from foreign tongues, has introduced into the Engliſh language. The technical phraſeology of every art and ſcience *muſt* become it, becauſe abſolutely neceſſary to its accurate expoſition. But foreign words unneceſſarily intermingled with Engliſh idioms, and Engliſh words in the conſtruction and arrangement of a foreign language, can never ſerve the intereſts of ſcience, and ought not to be employed in the enunciation of it. Chemiſtry, ſince it has aſpired above the laboratory of the alchemiſt, and the ſhop of the apothecary, ought to be arrayed in thoſe ſimple, yet dignified and elegant graces of writing, which are ſuitable to its philoſophical character. I have therefore laboured at once to make Fourcroy ſpeak pure, perſpicuous, intelligible Engliſh; and to preſerve ſtrictly the propriety, the peculiar phraſeology of the ſcience, and of the new theory. How far my endeavours may have been in this ſucceſsful, it is not for me to decide.

In ſo extenſive a work, executed in haſte, many little inaccuracies will, no doubt, ſtill remain.

A new tranſlation of Fourcroy's PHILOSOPHY OF CHEMISTRY is prefixed to the firſt volume of this tranſlation of the ELEMENTS, &c. It cannot fail to be uſeful as a SYLLABUS of all the general doctrines of the ſcience, and as a ſort of introduction to the larger work.

R. HERON.

PREFACE TO THE FOURTH EDITION,

BY THE

AUTHOR.

NO ſcience was ever more generally or more eagerly cultivated than chemiſtry has been during theſe laſt twelve or fifteen years: No ſcience ever made ſuch rapid progreſs in ſo ſhort a time. Theſe circumſtances render a fourth edition of this work neceſſary. The ſecond edition having been almoſt entirely ſold off in the ſpace of eighteen months, I had conſequently leſs time for improving it in a third edition, than I had for improving the firſt in it. In this edition, therefore, the work was enlarged only with one additional volume: but in the ſecond two had been added. Every elementary work, as it paſſes through ſucceſſive editions, muſt at length reach a period at which the judgement of the learned and diſcerning, will declare farther additions unneceſſary; and after which, review and careful corrections will be the only proper means of improving it. I am of opinion, that in the third edition my work reached that period. An account of the new diſcoveries ſince the year 1786 would not have added greatly to the bulk of the volumes: But by the advice of ſome judicious perſons, and in conſequence of underſtanding that beginners found ſome difficulties in the peruſal of this work, I was induced to alter and enlarge ſome chapters in the hiſtory of ſaline matters, of ſome of the metals, and of ſeveral of the immediate principles of vegetable and animal bodies. The additions made, in this *fourth edition*, to the contents of the third, are ſo few, as, all together, to enlarge the work but by a few pages in the compaſs of the whole five volumes.

When I compoſed, in the years 1780 and 1781, an abſtract of the fundamental facts of this ſcience, to ſerve as a ſyllabus to my lectures; I followed the ſame plan which I had before adopted in my lectures, and of which ſome years' experience had taught me the advantages. The unexpected ſucceſs of that work induced me to follow the ſame plan in the ſecond edition, publiſhed about ſeven years ſince. The encouragement which the ſecond and third editions have received from the proficients in chemiſtry and the friends of ſcience; and the preference which the rapid ſale and the various tranſlations authorize me to ſay, has been given to my work as an elementary book on chemiſtry through all Europe; induce me ſtill to adhere to the ſame plan which was laid down in the firſt edition. To alter my arrangement would have been in ſome meaſure to form a new work: yet I know not but it *might* be altered without any impropriety. Perhaps, the more correct knowledge which has been gained ſince the publication of my firſt edition; the more concluſive reaſonings; and the more accurate and numerous experiments with which chemiſtry has, ſince that time, been enriched; would render it advantageous to arrange the elements of the ſcience in an order ſomewhat different: To place, for inſtance, the hiſtory of all combuſtible bodies, ſulphur, coal, metals, &c. before that of acids; moſt of which ſalts are either burnt bodies, or compounds of combuſtible bodies. This would be to proceed from ſimple to compound: the acids of one kingdom would not then be ſeparated from thoſe of the other two kingdoms: only the differences between the principles of organic bodies and thoſe of minerals, would be treated of in diſtinct chapters. I have marked out a ſketch of this method in my Treatiſe on the Elements of Chemiſtry, intended for the uſe of the ladies, and the pupils of the Royal Veterinarian School *.

But although, in the preſent ſtate of chemiſtry, this laſt mentioned arrangement of its elements may be preferable; yet that which I at firſt adopted, and ſtill adhere to, is not without its advantages. It requires ſomewhat more particular attention from the ſtudent: but even in this inſtance, it is peculiarly favourable to his improvement. It exhibits the ſame facts in two different lights; it recals the mind a ſecond time to truths, which have been already ſubmitted to its view; and thus impreſſes more diſtinct ideas of the different phenomena, and of their mutual relations.

With reſpect to the theory laid down in theſe elements, the third edition was eſſentially different from the two former editions. In them, I appeared only as the hiſtorian of the different opinions which had prevailed among chemiſts. But, in the third edition, though I

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* School for the Medicine of Animals, which was eſtabliſhed at Alfort, near Paris.

I ſtill maintained the ſame impartiality, and gave an account of the principal theories which have been propoſed; yet I eſpouſed a ſide, and declared myſelf an entire convert to that doctrine which has received from ſome philoſophers the name of *pneumatic* or *antiphlogiſtic*. In this fourth edition, my opinion is ſtill more ſtrongly expreſſed in favour of the *pneumatic theory*; becauſe I am ſtill more entirely convinced of its truth. I flatter myſelf, that every unprejudiced perſon who ſhall carefully peruſe theſe elements, will find that this theory differs eſſentially from all others that have been hitherto propoſed; as it takes nothing upon ſuppoſition, admits no hypothetic principle, and conſiſts only in a fair detail of facts. I may even venture to ſay, that thoſe philoſophers who have not yet adopted this doctrine; particularly thoſe who have combated it in ſome inſtances with rather too much warmth, have not fully comprehended our meaning. They do not ſee that the ground of our opinions, the foundation on which our principles ſtand, is totally different from thoſe of other theories which occur in the ſtudy of phyſics. We only deduce plain inferences from a great variety of facts: we admit nothing not demonſtrated by experiments: and as we reject every hypotheſis, we cannot poſſibly commit ſuch blunders as thoſe into which the authors of all former ſyſtems of phyſics have fallen. Either I, and thoſe other modern chemiſts who have produced ſo many ingenious diſcoveries, are groſsly miſtaken; or the riſing generation of ſtudents, who are taught to reaſon in a very different manner from their predeceſſors, will renounce, as we have preſumed to do, the hypotheſes which have been ſo much agitated in the ſchools, and will confine themſelves to the reſults of fair experiments.

The modern *theory of chemiſtry*, which is denominated the *pneumatic*, and which denies the exiſtence of phlogiſton, is daily gaining new converts; and is already ſo generally received, that three fourths of the ſtudents, and eſpecially of the teachers of chemiſtry, may now be reckoned among its adherents. The two moſt eminent chemiſts in Europe, Dr. BLACK, and Mr. KIRWAN, after examining, with the utmoſt care, the new principles of the French chemiſt, and after contending againſt them for the ſpace of ten years; have, at laſt, with the candour becoming men of real genius and enlarged minds, frankly adopted them. "At laſt," writes Mr. Kirwan to M. Berthollet, in a letter dated on the 26th of January laſt, "I lay down "my arms, and abandon the cauſe of phlogiſton. I "clearly ſee, that there is no unequivocal experiment "to prove the production of fixed air from pure inflammable air. This being ſo, it is impoſſible to "maintain the doctrine of phlogiſton with reſpect to "metals, ſulphur, &c. Without deciſive experiments "we cannot form a ſyſtem, in oppoſition to poſitive "facts. I ſhall myſelf compoſe a refutation of my "own eſſay on phlogiſton."

Dr. BLACK thus expreſſes himſelf, in a letter to M. Lavoiſier:

"You have been informed of my endeavouring to "explain to my pupils the facts and principles of the "new ſyſtem which you have been ſo fortunate as to "diſcover, and which I begin to recommend, as being more ſimple, more uniform, and more conſiſtent

" with facts, than the old theory. And how could I " do otherwiſe? The many ſkillful experiments which " you have made in the great way, have been proſecuted through all their changing phenomena with " ſuch aſſiduous care, and ſuch ſcrupulous attention, " that nothing can be more ſatisfactory than the proofs " to which they have conducted you. The ſyſtem " which you have founded upon your facts, is ſo cloſely connected with them, ſo ſimple, and ſo eaſily " intelligible, that it muſt daily obtain increaſing approbation; and cannot fail to be adopted by a great " many chemiſts who have been long accuſtomed to " the old ſyſtem. You muſt not hope to convince " every perſon. You well know, that habit enſlaves " the minds of moſt men, and makes them believe " and reverence the greateſt abſurdities. I muſt confeſs to you, I myſelf have felt its influence. Having been accuſtomed for thirty years to believe and " teach the doctrine of phlogiſton, as it was underſtood before the diſcovery of your ſyſtem; I long " felt a degree of diſlike to the new ſyſtem, which repreſented that as an abſurdity, which I had regarded as ſcientific truth. But that diſlike, as it aroſe " only from the force of habit, has been gradually diminiſhed and overcome by the clearneſs of your demonſtration, and the ſolidity of your plan. Although there be ſtill ſome particular facts of which " the explanation ſeems difficult, and ſcarce ſatisfactory; I am, however, convinced, that your doctrine " is infinitely better founded than the old theory; and, " in this reſpect, cannot ſuffer by a compariſon with it. " But, if the power of habit ſtill hinder ſome old che-

" miſts from approving your ideas; the *young* cannot " be *influenced* by the ſame circumſtance: they will " univerſally rank themſelves on your ſide. We have " experience of this in our Univerſity, in which ſtu- " dents enjoy the fulleſt liberty in the choice of their " ſcientific opinions. They, in general, embrace your " ſyſtem, and begin to uſe the new nomenclature."

It cannot be ſaid, then, that the antiphlogiſtic doctrine has not gained many partizans; ſince it has been adopted by the greater number of the moſt celebrated natural philoſophers and profeſſors of chemiſtry in Europe; ſince almoſt all French chemiſts teach it in their lectures; and ſince, in oppoſition to twelve or fifteen chemiſts, in all Europe, who ſtill refuſe to admit this doctrine, there are more than fifty eminent profeſſors, and votaries of phyſical ſcience, who make it the baſis of their writings and lectures. How indeed ſhould a ſyſtem of doctrine fail to ſtrike all ſound and able minds with its beauty and luſtre,—which admits no hypotheſis,—inſiſts upon nothing but the reſults of facts,—explains moſt of the phenomena of nature and art, with a ſimplicity and a facility which were unknown before in phyſical ſcience? How ſhould experiments ſo carefully performed, and ſo accurate, or a logic ſo cogent and rational, fail to perſuade every unprejudiced mind? Let the hiſtory of modern chemiſtry be candidly ſtudied; let thoſe works be read with deep attention, and all thoſe diſſertations, which have been written within theſe ten years againſt the antiphlogiſtic doctrine; and it will ſoon be diſcerned, that thoſe chemiſts who ſtill combat this doctrine, may be divided into two claſſes. Of theſe, *one* part do not underſtand even the baſes of this doctrine, and appear to be ſtrangers to the train of experiments on which it is founded *. The prejudices of ſuch men are not to be overcome, or convinced: the long-formed habit of imperfect and inaccurate proceſſes, and the ſtrength of old opinions, abſolutely unfit them for new, general conceptions. The *other* claſs may be ſaid to be under the influence of a party ſpirit, and are more formidable. They are acquainted with our modern experiments; they ſay, that they have repeated them; they have themſelves made diſcoveries in this new chemiſtry: Yet,

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* M. Baumé has publiſhed, at the end of the new edition of his Elements of Pharmacy, an appendix, expreſsly intended to make an open declaration againſt the new doctrine, to deny the compoſition of water, and to decry the new nomenclature. It is unlucky for him, that every line in his book ſhews him not to have comprehended this doctrine; to calumniate without underſtanding it; to have repeated none of the experiments upon which it is founded, with ſufficient accuracy; and to be altogether a ſtranger to the ſpirit of modern phyſics. Works, whoſe authors thus betray their own ignorance, cannot deſerve reputation. Nor have we forgotten the unlucky fate of thoſe experiments and opinions of M. Baumé, which repreſented ſilices as convertible into argill by fuſion with alkalis; or thoſe which held forth a pretended production of boracic acid from fat and argill; or thoſe concerning the ſpontaneous irreductibility of the *Perſian precipitate;* the preparation of æthers, Starkey's ſoap, metallic ſalts, with exceſs of baſe, ſulphuric ſalts with exceſs of acid, &c. &c.

It is more ſurpriſing that ſuch warm objections ſhould have been made to the pneumatic theory by M. Monnet, who performed many valuable ſervices to chemical ſcience, before the diſcovery of the gaſſes. Without having thoroughly ſtudied, as it ſhould ſeem, the modern doctrine; without having ſufficiently acquainted himſelf with the new experiments and proceſſes which it has employed; he, with great heat, ſets

Yet, they attack the antiphlogiſtic theory with arms ſeemingly ſtronger than thoſe of the former claſs. The only difference between them and the antiphlogiſtians, conſiſts in their logic and mode of reaſoning. Inſtead of taking the ſhorteſt and moſt direct way to arrive at the end propoſed, they take a long, circuitous progreſs. What proves them not to be in the true road, is, that every one of theſe phlogiſtians forms a theory for himſelf in his own way, which has little or no connexion with any other theory: ſo that there are as many

different

ſets himſelf in oppoſition even to Scheele, to whom we owe many of thoſe diſcoveries, which other chemiſts have ſince confirmed; he talks of the oxalic acid, the oxigenated muriatic acid, the arſenic acid, as if he had never ſeen any of theſe acids, as if he had never obtained them in any of his proceſſes. He confidently pronounces, that no ſuch acids exiſts; that the pneumatic chemiſts are all miſtaken; and that their ſyſtem is not tenable. Yet, on reading his diſſertation againſt the pneumatic chemiſtry, which is inſerted in the fourth volume of the Memoirs of the Academy of Turin, it is eaſy to ſee that he has not fully comprehended the ſyſtem of the modern chemiſts; and, what is more inconceivable, that he has not performed any of his experiments with that accuracy, and thoſe proceſſes which were requiſite to procure the reſults which he refuſes to acknowledge. In a word, with his method of operating, and with that diſdain which he ſhews for the calculation of the proportions in analyſes, it was impoſſible that he ſhould rightly appreciate the modern diſcoveries; and he denies their exiſtence, becauſe they have, in fact, to him no exiſtence. We would wiſh perſons who have ſtudied the new chemiſtry, to read the diſſertations here cited. They will ſoon be convinced of the truth of our aſſertions, and will perceive the reaſons why, notwithſtanding ſo much oppoſition; the modern doctrine daily acquires new partizans, and whence it comes to reckon among its partizans, three-fourths of all that is eminent among the philoſophers of Europe.

different phlogiſtic theories, as there are philoſophers averſe to the antiphlogiſtic doctrine.

All the philoſophers who now admit the pneumatic doctrine, beſide being much more numerous than thoſe who oppoſe it, have alſo the advantage of being at one among themſelves. This ought to weigh deciſively with perſons engaged in the ſtudy of chemiſtry, if they cannot truſt to their own judgement, and determine for themſelves.

ELEMENTS
OF
NATURAL HISTORY
AND
CHEMISTRY.

PART I.

GENERAL FACTS; *and* INTRODUCTION *to the* WORK.

CHAP. I.

Definition of Chemiſtry; Chemical Proceſſes; and the Advantages of the Science, &c.

CHEMISTS have not generally agreed concerning the moſt proper definition of chemiſtry. Boerhaave, in his Elements, has ranked it among the arts, or, to ſpeak more accurately, has defined only the practical part of it. Chemiſtry, according to Macquer, is a ſcience, the object of which is to diſcover the nature and properties of all bodies by means of analyſis and ſyntheſis. This definition is indiſputably the beſt that has yet been given. But as analyſis and ſyntheſis cannot be employed with equal ſucceſs in inveſtigating the properties of all natural bodies, it would perhaps be better not to mention them at all when we attempt to define this ſcience. The chemiſt cannot attain the knowledge of the properties of bodies without bringing them into contact; and as all that he can poſſibly diſcover is only the mutual operations of bodies; perhaps the following definition may deſerve to be adopted, even in preference to Macquer's: CHEMISTRY IS THAT SCIENCE WHICH EXPLAINS THE INTIMATE MUTUAL ACTION OF ALL NATURAL BODIES. The facts which we are to relate will illuſtrate this definition. In order to diſplay the extent of this ſcience in an orderly and perſpicuous manner, we ſhall conſider the ſubjects upon which it is engaged; the means which it employs; the purpoſes it purſues; and the advantages which it affords.

§ I. *Concerning the Object, the Methods, and the Intentions, of Chemiſtry.*

THE *ſubjects* on which the labours of the chemiſt are engaged, are all the ſubſtances that compoſe the globe which we inhabit, whether buried in its interior parts or found at its ſurface. Chemiſtry is therefore of equal extent with natural hiſtory, and the ſame limits are common to both.

Analyſis or decompoſition, and *ſyntheſis* or combination, are the two *proceſſes* which chemiſtry employs to accompliſh its purpoſes. The firſt is nothing but the ſeparation of the conſtituent parts of a compound ſubſtance.

ſtance. Cinnabar, for inſtance, is a compoſition of mercury and ſulphur; the chemical art analyſes it by ſeparating theſe two bodies from one another. Till of late it was generally thought, and many are ſtill of opinion, that this method is more advantageous in chemical reſearches than the other. This opinion had even gained ſuch ground among the learned as to induce ſeveral of them to define chemiſtry, *The ſcience of analyſis*. But nothing can be more inconſiſtent with the juſt idea of decompoſition. In order to ſet this important truth in a proper light, we muſt divide analyſis into two kinds; the true or ſimple, and the falſe or complex. The *true analyſis* is that by which the component principles of the body decompoſed, are obtained, without ſuffering any alteration. The only criterion by which we can diſtinguiſh whether this analyſis has taken place, is when, by reuniting the ſimple ſubſtances to which the compound body has been reduced, we can form a new compound preciſely ſimilar to the former. Cinnabar will again furniſh an inſtance. When the two ſubſtances of which this compoſition is formed, namely mercury and ſulphur, are ſeparated by a chemical proceſs, they are found to be in a ſtate of purity ſimilar to that which they poſſeſſed before their ſeparation; for by uniting them we can form a new body, differing in no reſpect from the original cinnabar. But unfortunately for the ſcience, this kind of analyſis can ſeldom be effected. Chemiſts are not ſo happy as to be able to apply it to many of the bodies on which they make experiments. The neutral ſalts, and a few other mineral ſubſtances, are the only bodies in nature ſuſceptible of this ſpecies of decompoſition.

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The *falſe or complex analyſis* is that by means of which a body is reſolved into principles different from thoſe which appeared to exiſt in the compoſition, and incapable of forming, by their reunion, a body ſimilar to that from which they were obtained.

This kind of decompoſition takes place in moſt of the bodies that are ſubject to a chemical analyſis; no other condition being requiſite, but that more than two principles enter into the combination to be examined, and that they be united by a certain degree of mutual affinity. Many minerals, and all vegetable and animal ſubſtances without exception, admit of no other ſpecies of analyſis. Thus ſugar, diſtilled in a retort, affords an acid, an oil, and a carbonaceous reſidue; but all attempts to recombine theſe into the ſame ſubſtance from which they were obtained, are uniformly fruitleſs. This kind of analyſis cannot enable us to diſcover in what ſtate ſubſtances exiſted together in any combination before being ſeparated; and it therefore affords but little uſeful information, and is not to be truſted without the greateſt caution. By truſting too haſtily to reſults of this kind, chemiſts have afforded room for all that cenſure to which their art has been expoſed. On this account has chemiſtry been accuſed of abſolutely deſtroying bodies in its attempts to ſeparate their component parts; and we cannot but acknowledge that the cenſure was for a long time juſt: but becoming more circumſpect in proportion to her progreſs, chemiſtry now rejects that deceitful analyſis to which ſhe formerly had recourſe, and poſſeſſes the means of examining the properties and diſtinguiſhing the component principles of bodies, without deſtroying their nature. She even proceeds farther, and, as we ſhall have occaſion to mention more particularly when we come to treat of vegetable ſubſtances, eſtimates the mutual action of principles, and determines by what cauſes they are thus modified and changed.

Syntheſis or compoſition, the ſecond method of proſecuting chemical inquiries, is the formation of a compound by the artificial reunion of ſeveral principles. Its utility, its extent, and the dependance that may be placed on the reſults which it affords, render it much more valuable than the other: nay, not even a ſingle operation in chemiſtry can be conducted without producing ſome new combination. Chemiſts appear not to have been ſufficiently ſenſible of its importance. In fact, as ſyntheſis is both more frequently employed and more highly uſeful than analyſis, chemiſtry might be, with a good deal of propriety, repreſented as the ſcience of combination, not of analyſis.

Theſe two methods are ſometimes employed ſeparately, but oftener together. It frequently happens that a true analyſis cannot be effected without the help of ſome combination. Falſe analyſes are always accompanied with new combinations by ſyntheſis; nay, compoſition itſelf often produces a kind of analyſis. The laſt of theſe facts, however, has been but lately diſcovered. The diſcovery of a great number of aeriform fluids, the exiſtence of which was not formerly ſo much as ſuſpected, has ſhown that in many operations which were conſidered as ſimple combinations, an inviſible elaſtic fluid is diſengaged with effervefcence, and either eſcapes into the atmoſphere, or is received in veſſels which have been ingeniouſly contrived to confine it. Moſt of the combinations of two principles which were before thought to be ſimple ſubſtances, exhibit this kind of analyſis. We ſhall have occaſion to give frequent inſtances of it, when we come to treat of neutral ſalts.

From this ſhort account of the analyſis and ſyntheſis of the chemiſts, it appears that the whole art of chemiſtry conſiſts in promoting the intimate mutual action of bodies, and in obſerving carefully the phenomena with which it is attended. It is to be remembered, that Nature herſelf conſtantly employs theſe two methods, and that from her the chemiſt firſt learned to uſe them. As they depend on the mutual affinities of bodies, all that the artiſt can do is to diſpoſe theſe in ſuch a manner that they may act upon each other. The young chemiſt ought carefully to acquaint himſelf with theſe important truths: for theſe, with the reſt to be explained in the following chapters of this firſt part, form the baſis of the ſcience.

Hence it is very eaſy to comprehend the final intention of chemiſtry. That cannot be merely to diſcover the firſt principles of bodies; for there are many ſubſtances which cannot be reſolved into others more ſimple, and whoſe component principles are therefore unknown: yet theſe ſubſtances, though not ſuſceptible of analyſis, admit of combination, and act upon other bodies; and therefore it appears evident, that the chief deſign of chemiſtry is to diſcover the mutual actions of natural bodies, to diſtinguiſh the order of their combinations,

nations, and to eſtimate the ſtrength of that mutual attraction which gives them a tendency to unite and to remain in union.

§ II. *Concerning the uſeful Purpoſes to which Chemiſtry may be applied.*

A Particular treatiſe would be neceſſary to give a full view of all the advantages which mankind derive from this ſcience. As the deſign of this work does not admit of our entering minutely into that ſubject, we ſhall content ourſelves with exhibiting its outlines; inſiſting, however, more particularly on ſuch of them as appear not to have been hitherto conſidered with all the attention which they deſerve.

Chemiſtry is beneficial to ſo many of the arts, that we may arrange them all under two diviſions: the firſt, comprehending all the mechanical arts which depend on the principles of geometry; the ſecond, including all thoſe which depend upon chemiſtry, and therefore merit the name of chemical arts. Theſe laſt are much more numerous than the other. As they are all founded on chemical phenomena, it is eaſy to ſee that the practice of them ought to be regulated by the rules of chemiſtry; which, by new diſcoveries, ſimplifies the proceſſes, renders their ſucceſs more certain, and even extends the limits of all the arts dependant upon it. Theſe are, 1*ſt*, The arts of making bricks, tiles, china, porcelain, and the other ſpecies of earthen ware; all of which are preparations of different kinds of clay, baked into different forms, and expoſed to the action of heat till each may have acquired its proper degree of hardneſs. *2dly*, The art of making glaſs; which, by combining a vitrifiable earth with a ſaline ſubſtance, produces a new body, hard, tranſparent, and almoſt impregnable by the action of the air: A wonderful art, from which mankind have derived many important advantages! *3dly*, The arts of extracting metals from their ores, of caſting, of purifying, and of alloying them by mixture, owe alſo their origin and progreſs to chemiſtry, which is daily throwing new light upon them. *4thly*, The vegetable kingdom affords materials to a great number of arts, which, as well as thoſe above-mentioned, belong to the province of chemiſtry. The arts of converting ſaccharine juices, or farinaceous ſubſtances, into vinous liquors; of extracting from theſe liquors the ardent ſpirit which they contain; of ſeparating that ſpirit from the water with which it is at firſt combined; of uniting this ardent ſpirit with the aromatic parts of plants; of extracting the colouring matter of plants, and applying it ſo as to tinge ſtuffs; and, laſtly, the arts of converting wine into vinegar, and combining vinegar with various ſubſtances; of ſeparating from grain and other parts of vegetables that precious ſubſtance of which we form bread; and of converting ſo dry and inſipid a body as meal, into a light, digeſtible, and pleaſant ſubſtance; all theſe arts, and many more, which our preſent limits allow us not to take particular notice of, belong to the province of chemiſtry, and are indebted to this ſcience for their preſent perfection, and in many inſtances for their firſt invention *.

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* The *art of bleaching* is wholly chemical.—H.

It has equal claims to the honour of being the miſtreſs or parent of all thoſe arts which are employed on animal ſubſtances. Such is the uſeful art of cookery; the true end of which is not to flatter the palate, or to vary the forms and flavours of meats, for the gratification of capricious taſte; but to render aliments eaſy of digeſtion, by means of boiling, or by applying to them mild and natural ſeaſoning. Hat-making, and the dreſſing, tanning, and currying of leather, belong to the ſame claſs of arts. But one of the moſt valuable of all the arts, which indeed occupies a middle rank between the arts properly ſo called, and the ſciences, and to which chemiſtry is ſingularly uſeful, is pharmacy. Every perſon concerned in pharmacy needs a very extenſive knowledge of chemiſtry, that he may not be ignorant of thoſe alterations to which the bodies he makes uſe of are ſubject; may know how to prevent or correct ſuch alterations; may be enabled to diſcover the changes which compound medicines undergo; and, in a word, may foreſee readily the combinations or analyſes that may be produced by the mixture of any ſimple drugs. Every impartial perſon muſt agree, that to acquire a competent ſkill in pharmacy, the ſtudent ought, after acquainting himſelf with the natural hiſtory of the materia medica, to turn his attention to chemiſtry, and ſtudy it with the moſt earneſt aſſiduity. By theſe means only, can pharmacy be practiſed on certain principles, ſo as to render to mankind thoſe important ſervices which entitle it to the high rank it holds among the arts *.

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* It is probable that *agriculture* may be greatly benefited by the application

A very curſory view of the ſciences will be ſufficient to convince us of what important benefits they may derive from chemiſtry. To natural hiſtory it is peculiarly beneficial. The earlier naturaliſts employed the phyſical properties of colour, form, conſiſtency, &c. as the diſtinguiſhing characteriſtics of minerals: but theſe properties being very liable to variation, the bodies of which ancient philoſophers have ſpoken are no longer known, and their diſcoveries are almoſt totally loſt. The moderns have become ſenſible, that, in order to obviate this inconvenience ſo fatal to the progreſs of natural hiſtory, ſome new method muſt be adopted. Chemical analyſis has been thought the happieſt that can be employed; and by this method ſuch progreſs has already been made, that minerals are now arranged in claſſes according to the nature and quantity of the principles of which they are compoſed. The progreſs made in this branch of natural hiſtory is owing to the labours of Meſſrs Bergman, Bayen, Monnet, &c. Wallerius, Cronſtedt, and ſome other naturaliſts, firſt began the arrangement of mineral bodies according to their chemical properties. M. Bucquet, in his latter courſes of lectures, had improved on the ideas of thoſe two celebrated naturaliſts; and his mode of arrangement was entirely chemical. M. Sage, who has analyſed a great number of minerals, has alſo employed a chemical mode of arrangement: and though no chemiſt has

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application of chemiſtry to diſcover the operation of *manures*, and the principle of fertility in ſoils. *Lord Dundonald's* late work, and *Dr Kirwan's eſſay* in the *Tranſactions* of the *Royal Iriſh Academy*; are laudable attempts in this way.—H.

has adopted the whole of his theory, yet mineralogy owes to him the higheſt obligations; and few in France have purſued the ſtudy with greater induſtry and ſucceſs. M. Daubenton has availed himſelf of the labours of all his cotemporaries and predeceſſors; examining them, however, with a degree of caution worthy of the true philoſopher, whoſe proper object is to diſcover truth amid that maze of error and uncertainty, in which, unfortunately for mankind, it is too often concealed. Nothing, then, can be more certain than the utility of chemiſtry to natural hiſtory; it affords the only means of removing that obſcurity and uncertainty which muſt ever attend ſimple deſcriptions of natural objects. One obſervation of M. Daubenton merits the particular attention of all chemical philoſophers: He adviſes them to deſcribe carefully the ſpecimens on which they make their experiments, in order that they may be generally underſtood by naturaliſts, and may avoid that confuſion which, according to this celebrated profeſſor, prevails through the works of many modern chemiſts. The only means which I have found proper for avoiding that confuſion, is, to connect the two ſciences in my lectures, by uniting phyſical deſcriptions of bodies with an account of their chemical properties.

But the world are not ſo generally convinced of the uſefulneſs of chemiſtry in medicine. The errors of the chemical phyſicians of the laſt century, and the indifference of a number of medical practitioners for this ſcience, have impreſſed many with an unfavourable opinion of it, which time alone can remove. Yet, it would ſurely be better not to lend an ear to the voice of prejudice, but to inquire candidly into the cauſes of thoſe miſtakes which chemiſts have committed, and to conſider by what means they may be for the future avoided, and the ſcience reſtored to its juſt honours. Though the firſt phyſicians who cultivated chemiſtry were miſled by a blind enthuſiaſm; yet from that no inferences can be drawn applicable to the chemiſtry of the preſent time. The preciſion which the moderns have introduced into every part of experimental philoſophy, cannot but remove all the apprehenſions which might be entertained, if chemiſtry were ſtill involved in the ſame degree of myſtery and obſcurity in which it was a century ago. If employed with caution, and with a due regard to the extent of its powers, it cannot but be highly beneficial to medicine. After thus acknowledging the whims and blunders of chemiſts, let us proceed to juſtify the ſcience, by examining how far it is uſeful to every branch of medicine. Let us firſt diſtinguiſh between the two great departments of this extenſive ſcience, namely, the theory and the practice; which, however, ought not to be entirely ſeparated from each other, as they have been by ſome authors. The ſtudy of medicine ought always to begin with the anatomy of man and the other animals. But the ſolids are the only part of the animal frame ſubject to the examination of anatomy; while it is well known to phyſiologiſts, that the greateſt part of animal bodies conſiſts of fluids, by the motion of which life is maintained. Were we then to confine our obſervation to the ſtructure of the veſſels, without examining the nature and properties of the fluids which they contain, we ſhould be acquainted with only one part of the animal ſyſtem. It is the buſineſs of chemiſtry to explain to us the qualities of theſe fluids: chemiſtry affords the only means by which we can acquire a knowledge of the principles of which they are compoſed, and of the changes which they undergo in performing thoſe functions by which they contribute to the ſupport of life. Without the aid of this ſcience, it would be impoſſible for us to diſcover the mechaniſm of the animal functions; to diſtinguiſh between the various fluids ſeparated by the different viſcera; to obſerve what alterations theſe ſuffer when collected in their ſeveral reſervoirs; or to underſtand how they are affected by heat, cold, or mixture with other fluids, &c. When we are thus far acquainted with the compoſition of animal fluids, it will next be proper to examine what variations they are liable to, from differences of ſex, age, conſtitution, climate, and ſeaſon; and to trace them through the various ſpecies of animals. Thus ſhall we eſtabliſh certain points of compariſon, by means of which the limits of ſcience may be extended. It is not enough, however, to examine the chemical properties of the animal fluids when the ſyſtem is in a ſound ſtate: they ſhould be obſerved with no leſs attention when the body languiſhes under diſeaſe, in order that it may be certainly diſcovered what alterations they ſuffer in the various diſtempers to which the human frame is liable; what part of the humours predominates in putrid, inflammatory, ſcorbutic, or ſcrophulous diſorders; what ſaline combinations are formed during the progreſs of the diſtemper; what matter extruded from its proper veſſels. Such reſearches cannot fail to make phyſicians better acquainted with the hiſtory of pathology. We think it equally neceſſary to examine the ſolids by chemical methods, in the ſound as well as in the diſeaſed ſtate of the body; that by conſidering their properties, we may diſcover from what fluid they are produced; and, this known, may conjecture upon good grounds, what ſolid or fluid has ſuffered alteration in any diſtemper. This poſition, which is here but ſlightly mentioned, will be more particularly explained in the chapters on Animal Matters.

But chemiſtry is no leſs uſeful to the practice than to the theory of medicine; nor can it indeed be uſeful to the one without promoting the other at the ſame time. It will, therefore, be no difficult taſk to ſhow the dependance of the practice upon the ſcience. To begin with the art of preſerving health; an accurate chemical knowledge of the various articles of food, and of the atmoſpheric fluid, is neceſſary to enable us to make a proper choice of air and aliments. By chemiſtry we learn what quantity of nutritive matter is contained in every different article of food; in what particular ſtate that matter exiſts in each of the bodies in which it is found; the nature of the ſeveral ſubſtances with which it may be combined; and the means of extracting, purifying, and preparing it in a manner ſuitable to the ſtrength or weakneſs of different ſtomachs. It is the ſame ſcience that explains to us the nature of thoſe fluids which we uſe to drink; what properties render water wholeſome or noxious, and how to ſeparate from it whatever may render it injurious to the animal œconomy; what are the principles of fermented liquors, and in what proportion thoſe are mingled together in the ſeveral kinds of wine ; as alſo by what proceſſes we may diſtinguiſh whether wine be genuine or adulterated. Laſtly, by the ſame means we learn, what properties render air fit for reſpiration ; to what changes this fluid is liable ; and what other ſubſtances are capable of altering its purity, by entering into combination with it. Chemiſtry likewiſe ſupplies us with the happy means of correcting the qualities of air when noxious, ſo as to reſtore it to that ſtate in which it is proper for reſpiration : for the diſcovery of which means we are indebted to the induſtry of the moderns, as will be ſhown in the Hiſtory of Air *.

The phyſician ought not to make uſe of medicines unleſs he know their nature ; and this knowledge he muſt learn from chemiſtry. This has been ſo long generally acknowledged, that the writers of the materia medica arrange medicines by their chemical properties. The uniform experience of all ages has eſtabliſhed it as a certain truth, that there is a cloſe and natural relation between the taſte of bodies and the manner in which they act on the animal œconomy ; ſo that by taſting any ſubſtance we may judge of its medicinal qualities : Bitters are ſtomachic ; inſipid ſubſtances, mild and relaxing ; bodies of an agreeable ſweet taſte, nutritious ; acid

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* The application of aëriform fluids to the cure, particularly of *conſumption* and *cancer* ; which has been attempted in Britain, by *Drs. Beddoes*, *Ewart*, *Darwin*, and others ; if finally ſucceſsful in ſuch a number of unequivocal caſes, as may recommend it to the practice of phyſicians in general ; will greatly enlarge the range of the utility of chemiſtry in medicine.—H.

acid ſubſtances, active, penetrating, and inciſive. But as taſte is undeniably a chemical property, depending on the tendency of ſubſtances to combination, as ſhall be elſewhere ſhown, we muſt confeſs ourſelves indebted to chemiſtry for whatever knowledge of the properties of bodies we can gain by examining their taſte. Yet it would be abſurd to ſuppoſe, with the chemical phyſicians of the laſt century, that the ſtomach is a veſſel in which chemical proceſſes are carried on, as in a laboratory. The inteſtines poſſeſs indeed ſenſibility and a peculiar motion, which modify the nature and operation of ſuch medicines as are adminiſtered; but it becomes the phyſician to repreſs thoſe wild ſallies of imagination which lead to ridiculous hypotheſes, and to admit only ſuch facts as are eſtabliſhed by accurate obſervation. It cannot be denied, that, in ſome caſes, medicines act in the firſt paſſages by means of their chemical properties: then, indeed, the phyſician may apply his chemical knowledge. Long experience has ſhown, that in the diſeaſes peculiar to children, the ſtomach and inteſtines are coated with a tenacious viſcid matter, which is manifeſtly of an acid nature. The abſorbent earths, and alkalis adminiſtered on ſuch occaſions, deſtroy this acid by entering into combination with it, and form a neutral purgative ſalt, which by ſtimulating the inteſtines, cauſes them to evacuate the noxious matter. All diſeaſes that occaſion an accumulation of obſtructive matter in the primary paſſages, require the phyſician to poſſeſs ſome chemical knowledge; as it is certain that ſome ſubſtances will act with more force than others on that obſtructive matter. Thus, for inſtance, acids may be adminiſtered to remove one kind of obſtruction, and a ſolution of ſalts for another.

But the greateſt advantage which the practitioner of medicine can derive from chemiſtry, is on thoſe alarming occaſions when, by accident or deſign, ſome of thoſe corroſive ſubſtances have been ſwallowed, which prove fatal to life by attacking the viſcera, and deſtroying their organization. On ſuch occaſions chemiſtry lends the readieſt and moſt effectual aid to medicine, by ſupplying ſubſtances which have power to decompoſe the poiſon, and by that means obviate its direful effects. Navier, a celebrated medical chemiſt of Chalons, has publiſhed a work, in which he points out effectual remedies to prevent the deſtructive effects of the poiſons of arſenic, corroſive ſublimate, verdegris, or the preparations of lead. Notwithſtanding the angry declamations of ſome phyſicians, who ſeem deſirous of excluding the ſciences from the practice of medicine, his work well deſerves the gratitude of poſterity. Not only does chemiſtry at preſent enable us to counteract effectually the operation of mineral poiſons; but there is even reaſon to hope, that careful inquiries into the nature of animal and vegetable poiſons, may enable us to diſcover ſome ſubſtances capable of diveſting them alſo of their pernicious powers. Opium, and all narcotic vegetables, the acid and cauſtic juices, ſuch as thoſe of ſpurge and euphorbium, the noxious plants, particularly muſhrooms, are all well worthy of the particular attention of the chemiſt; as by his reſearches ſome means may poſſibly be diſcovered which may render them hereafter leſs dangerous. It is of no leſs importance to examine the nature of animal poiſons. From the experiments of Margraaf and Fontana we are already acquainted with the acid of ants: Thouvenel has diſcovered ſeveral acrid ſubſtances in cantharides: Mead has examined the venom of the viper: Fontana has purſued a train of inveſtigation concerning the ſame poiſon; and has diſcovered, that *lapis cauſticus*, introduced immediately into the wound made by this reptile, decompoſes the poiſon, and prevents its effects.

Did chemiſtry even contribute leſs in theſe inſtances to the benefit of medicine; yet ſtill by ſupplying ſuch a number of valuable drugs, ſhe muſt be confeſſed to render ſervices of the higheſt importance to this uſeful ſcience. *Stibiated* tartar, together with the various mercurial, antimonial, and martial preparations, which are ſo often and ſo ſucceſsfully preſcribed, when conſidered as the gifts of chemiſtry, muſt ſurely induce phyſicians to eſteem the ſcience, and to encourage thoſe who proſecute chemical reſearches from a deſire to contribute to the advancement of medicine. As for myſelf, the natural bent of my genius, no leſs than my particular ſituation, leads me to cultivate both theſe ſciences with the moſt earneſt wiſhes to promote their improvement. The declamations of thoſe, who from their ignorance of chemiſtry, are induced to repreſent it as of no utility in medicine, ſhall never detach me from its purſuits. I have engaged with ardour in the ſtudy of animal chemiſtry, and am determined to follow the ſteps of thoſe who have already proſecuted it with ſo much ſucceſs.

To conclude our obſervations on the utility of chemiſtry to medicine: we ſhall only add, that a certain degree of chemical knowledge is abſolutely neceſſary to enable the phyſician to make out a preſcription of any compound medicine, to be prepared by the apothecary. Perſons unſkilled in chemiſtry are liable to commit the groſſeſt blunders daily in making out preſcriptions; to order, for inſtance, the compoſition of ſubſtances incapable of ſubſiſting in union, or which have a mutual tendency to decompoſe one another. In the caſe of decompoſition, the medicine adminiſtered cannot poſſibly produce the deſired effects. Chemiſtry furniſhes the only means to prevent ſuch blunders; which are often attended with the moſt unhappy conſequences. If poſſeſſed of chemical knowledge, we will never attempt to compound together ſubſtances incapable of mutual combination; the laws of chemiſtry muſt always direct us in the preparation of compound medicines. Without a knowledge of chemiſtry, the phyſician muſt ever be liable to commit numerous blunders; which, though they ſhould be followed by no other bad conſequences, cannot but expoſe him to the contempt of the apothecary; as the practice of the apothecary naturally makes *him* acquainted with many chemical facts.

The uſefulneſs of chemiſtry in the arts, and the reſemblance of its proceſſes to the manipulations of artiſts, have cauſed it to be confounded ſometimes with alchemy, ſometimes with pharmacy; though *they* muſt be very ignorant indeed, who can thus confound objects ſo widely different from one another, and can regard the chemiſt as a fanciful projector, unweariedly employed in a vain ſearch for the philoſopher's ſtone. Even a very ſlight attention to the nature and purſuits of chemiſtry, may be ſufficient to convince any perſon that there is a vaſt difference between thoſe purpoſes which the chemiſt purſues in a train of regular connected reſearches, and the tranſmutations which the alchemiſt pretends to effect by a ſet of abſurd and deſultory proceſſes. That miſtake which leads many people to regard chemiſtry as the art of preparing drugs is more excuſable; it confounds not the chemiſt with the ignorant and inſignificant operators of the Great Work; who, as is humorouſly obſerved by Macquer, are the artiſans of an art which has no exiſtence; but aſſociates him with a claſs of uſeful and reſpectable artiſts, whoſe labours are of high importance to ſociety. Yet as pharmacy is but one branch of chemiſtry, to confine chemiſtry to the making up of medicines, is to entertain a very unjuſt idea of the extent of the ſcience. Pharmacy, as well as all the other arts dependant on chemiſtry, is guided and aſſiſted in its operations by this ſcience. But chemiſtry, in its nature and objects, is more ſublime and extenſive; it extends its inquiries and inductions to the reciprocal action of all the bodies in nature; and thus contributes at the ſame time to the advancement of both philoſophy and the arts.

CHAP.

CHAP. II.

The Hiſtory of Chemiſtry.

THE ſtudent of any ſcience ſhould make himſelf acquainted at leaſt with the outlines of its hiſtory. A knowledge of the leading facts, and of the dates of different diſcoveries, will be of uſe to enable him to avoid the errors of thoſe who have preceded him in the ſame purſuits, and to direct him to the path which leads to improvement. But as a very minute detail of the hiſtory of chemiſtry might poſſibly be conſidered as an unneceſſary digreſſion from the main object of this treatiſe, we ſhall confine ourſelves to a view of leading facts, without entering into particulars. Whoever is deſirous of fuller information concerning the riſe and progreſs of chemiſtry, may conſult a variety of well-written works which have been publiſhed on the ſubject; particularly, the Treatiſe of Olaus Borrichius, *de ortu et progreſſu Chemiæ;* the article *Chimie* in the *Dictionnaire Encyclopedique;* the Introduction to Senac's Treatiſe on Chemiſtry; Abbé Lenglet du Freſnoy's Hiſtory of the Hermetic Philoſophy; the firſt Chapter of Boerhaave's Chemiſtry; the Diſcourſe perfixed to Macquer's Chemical Dictionary; Bergman's Eſſay on the Hiſtory of Chemiſtry, &c.

To give the reader a brief and methodical account of the progreſs of the human mind in the ſtudy of chemiſtry, and of the ſucceſſive diſcoveries which have been made in this ſcience; we ſhall divide our hiſtory into ſix periods.

I.

The origin of Chemiſtry among the Egyptians, and its progreſs among the Greeks.

THE origin of chemiſtry is hid in the ſame obſcurity which conceals that of the other arts and ſciences. The patriarch Tubal-Cain, who lived before the flood, is conſidered as the inventor of chemiſtry; but the only part of it known to him was the art of working metals: he ſeems to have been the ſame with the Vulcan of fabulous hiſtory.

We may with more confidence aſcribe the invention of this ſcience to the ancient Egyptians. According to Abbé Lenglet du Freſnoy, Thoth or Athotis, ſurnamed Hermes or Mercury, is the firſt of this nation of whom mention is made as being a chemiſt. He was the ſon of Mezraim or Oſiris, and the grandſon of Cham. He became king of Thebes.

Siphoas was the next Egyptian monarch, who was alſo diſtinguiſhed as a philoſopher. He lived 800 years after Athotis, and 1900 before Jeſus Chriſt. He is named Hermes, or Mercury Triſmegiſtus, by the Greeks; and is therefore the ſecond Mercury: he is conſidered as the inventor of natural philoſophy; he wrote two and forty books on the ſubject of philoſophy, the titles of which have been handed down to us by various hiſtorians. None of them ſeems to have treated directly of chemiſtry; though from him has the ſcience been intitled the Hermetic Philoſophy.

We know but little concerning thoſe who cultivated chemiſtry among the Egyptians; but the ſcience appears to have made conſiderable progreſs among them, for they practiſed many of the arts dependant on chemiſtry; particularly the arts of forming imitations of the precious ſtones, of caſting and working metals, of painting upon glaſs, &c.: but the chemiſtry of this ancient people has been loſt, as well as their other arts and ſciences. The prieſts involved them in myſtery, and concealed them under the veil of hieroglyphics. Alchemiſts have perſuaded themſelves, that ſome veſtiges of their pretended art may be traced among the remains of the Egyptian hieroglyphics; and that the temple which the Egyptians dedicated to Vulcan was erected in honour of alchemy.

The Iſraelites acquired a knowledge of chemiſtry from the Egyptians. Moſes is conſidered as a chemiſt, on account of his diſſolving the golden idol which the people had ſet up. It has been thought, and Stahl has even written a diſſertation to prove, that he rendered the gold ſoluble in water by means of liver of ſulphur. Such a proceſs ſuppoſes a pretty extenſive knowledge of chemiſtry.

Democritus of Abdera, who lived about 500 years before Jeſus Chriſt, travelled into Egypt, Chaldea, and Perſia, &c. and is ſaid to have gained ſome ſkill in chemiſtry in the firſt of theſe countries. Though the ſon of a man whoſe opulence had enabled him to entertain Xerxes and all his attendants, he returned very poor to his native country, where he was kindly received, however, by his brother Damaſſus Retiring to a garden near the walls of the city of Abdera, he employed himſelf in the ſtudy of plants and precious ſtones. Cicero aſſerts, that Democritus, in order that he might not be diverted from his ſpeculations by external objects, deprived himſelf of ſight by gazing on the rays of the ſun reflected from a veſſel of poliſhed copper: But Plutarch denies this fact. Pliny was ſo amazed at the knowledge of Democritus, that he conſidered it as quite miraculous.

Some authors reckon Cleopatra a chemiſt, becauſe ſhe knew how to diſſolve pearls. It is even affirmed, that the art of chemiſtry being known to all the Egyptian prieſts, continued to be practiſed among that nation till the time when, according to Suidas, Diocleſian thought to reduce them more eaſily under ſubjection, by burning their books on chemiſtry.

II.

The Chemiſtry of the Arabians.

After a long ſeries of ages, through which it is impoſſible to trace the progreſs of chemiſtry amid the revolutions of empire; this ſcience again appears among the Arabians, and cultivated ſo ſucceſsfully as to merit our attention.

Under the dynaſty of the Achemides, or Abaſſides, the ſciences, which had long been neglected, regained their former vigour. Almanzor, the ſecond Caliph of this family, eagerly cultivated aſtronomy. Harum Raſchid, the fifth Caliph, who was cotemporary with Charlemagne, cauſed ſeveral books on chemiſtry to be tranſlated from the Greek into the Arabic.

In the ninth century, Gebber of Thus, in Chorazan, a province of Perſia, wrote three different treatiſes on chemiſtry; which contain a number of tolerably good things. His maſterpiece is entitled, *Summa perfectionis magiſterii.* He has written with conſiderable perſpicuity on diſtillation, calcination, the reduction and the ſolution of metals.

In the tenth century, Rhazes, phyſician to the hoſpital of Bagdad, firſt applied chemiſtry to medicine. Some of his pharmaceutic preſcriptions are ſtill in eſteem.

In the eleventh century, Avicenna, a phyſician, in imitation of Rhazes, applied chemiſtry to medicine. His merit raiſed him to the office of Grand-Vizir; but his debaucheries occaſioned his degradation from that office.

III.

Chemiſtry paſſes from the Eaſt to the Weſt, in the time of the Cruſades: Reign of Alchemy.

THE art of making gold continued long in repute, according to the authors who have written upon it. But the madneſs that gave riſe to it was at its greateſt height between the eleventh and the ſixteenth century. The chemical facts which had been diſcovered by the Egyptians, collected by the Greeks, and applied to medicine by the Arabians, became known to the four nations who viſited the eaſt in the Cruſades; and England, France, Germany, and Italy, ſoon ſwarmed with a ſet of men eager in ſearch of the philoſopher's ſtone. As their labours contributed to the advancement of chemiſtry, it is but reaſonable to take notice of ſome of the moſt diſtinguiſhed among thoſe ſingular geniuſes.

In the thirteenth century, Albert the Great, a Dominican of Cologn, and afterwards of Ratiſbon, was reputed

ted a magician; and compoſed a work, which contains deſcriptions of many alchemical proceſſes.

Roger Bacon, born in the year 1214, near Ilcheſter in the county of Somerſet, ſtudied at Oxford, and came afterwards to Paris to proſecute his ſtudies in mathematics and medicine. He is celebrated as the author of ſeveral inventions; any one of which might well intitle him to immortality. Among theſe are the camera obſcura, the teleſcope, and gunpowder. He is ſaid to have made a ſelf-moving chariot, a flying machine, a ſpeaking head, &c. He was a cordelier, and was ſirnamed the *Admirable Doctor.* Being accuſed of magic, his fellows were obliged to impriſon him. He afterwards reſided in an houſe in Oxford, where he is ſaid to have worked in alchemy Borrichius ſaw the houſe, which was ſtill known by his name *.

Arnold of Villeneuve, born in Languedoc in 1245, died in 1310, having ſtudied medicine at Paris for 30 years. He wrote a commentary on the Schola Salernitana. The alchemiſts reſpect him as one of their greateſt maſters. Borrichius, in the year 1664, ſaw one of his deſcendants, an alchemiſt, in Languedoc.

Fourteenth century. Raymond Lully, born in Majorca in 1235, came to Paris in 1281; where he became acquainted with Arnold of Villeneuve, and ſtudied under him. Robert Conſtantine relates that he had ſeen in the Tower of London, a Roſe Noble ſtruck out of gold, made by Lully, under the reign of Edward V. in the years 1312 and 1313. He has left ſeveral books on alchemy, which contain ſome facts relative to the preparation of acids, or aquafortis, and the properties of metals.

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* Concerning this houſe, if I miſtake not, a tradition has been long known at Oxford; that when a greater man than Roger Bacon paſſes beneath it, it will tumble down upon his head. It ſtands on a bridge.

"And Bacon's manſion trembles o'er his head." JOHNSON.—H.

Fifteenth century. Baſilius Valentinus, a Benedictine of Erfort in Germany, was ſkilled in medicine and natural hiſtory. He has left a work on antimony, under the pompous title of *Currus triumphalis Antimonii*, on which a commentary has been written by Kerkringius. This book deſcribes a conſiderable number of antimonial preparations, which have been ſince offered to the world as new diſcoveries, under different names, and have been preſcribed with great ſucceſs for the cure of ſeveral diſorders.

The two Iſaacs of Holland, father and ſon, though but little known, have left ſome treatiſes which are praiſed by Boerhaave, and from which they appear to have been acquainted with aqua fortis and aqua regia.

All theſe authors have written on chemiſtry in a very obſcure confuſed manner Though acquainted with ſome proceſſes of ſolution, extraction, and purification, &c. their pretenſions roſe much higher than their knowledge; and ſcarce any advantage can be derived from a peruſal of their works.

IV.

The univerſal Medicine; Pharmaceutic Chemiſtry; Alchemy oppoſed, from the ſixteenth to the middle of the ſeventeenth Century.

THOUGH the vain projects of the alchemiſts had been invariably unſucceſsful, and had been almoſt always attended with the loſs of fortune and reputation; yet, in the ſixteenth century, a prodigious number appeared; at the head of whom was Paracelſus, a Swiſs phyſician, born at Zurich in 1493, whoſe reveries were eagerly embraced by the reſt. This fanciful man aſſerted, that there was an univerſal medicine, and ſubſtituted chemical preparations in the place of the Galenical pharmacy then in uſe. He cured many diſeaſes in which the ordinary remedies had been ineffectually applied, and particularly venereal complaints with mercurial preparations. He performed ſome very ſurpriſing cures; but became ſo extravagantly fluſhed with his ſucceſs, as to burn in public the writings of the Greek phyſicians. He died amid his imaginary triumphs, in an inn in Saltzburgh, at the age of 48, after having promiſed himſelf immortality from the uſe of his ſecrets.

Notwithſtanding the extravagance and abſurdity of his idea of an univerſal medicine, it attracted the attention of alchemiſts, and revived the ſpirit of alchemy. Several imagining that they had diſcovered the univerſal medicine, aſſumed the new title of *Adepts*. Among theſe were, at the beginning of the ſeventeenth century,

1. The Roſicrucians, a fraternity that aroſe in Germany, were never known but by name in France, and whoſe individual members never made any public acknowledgement of their principles: They pretended to be in poſſeſſion of the art of tranſmutation, the univerſal ſcience, the univerſal medicine, and the ſcience of occult things, &c:

2. A wandering fellow, named Alexander Sethon or Sidon, who is ſaid to have performed the work of tranſmutation in Holland, in the preſence of a perſon of the name of Hauſſen: Hauſſen related the fact to

Vander Linden, grandfather to the phyſician of that name, who collected a medical library:

3. Another named Thomas Vaughan, born in England in 1612. He went to America, where Starkey ſaw and received gold from him. Boyle correſponded with him. This is the ſame adept who, in France, gave his powder of projection to Helvetius. The latter, in conſequence of this pretended miracle, which was nothing but a trick, wrote a diſſertation *De Vitulo aureo*, &c.

Yet the ſucceſs with which Paracelſus had preſcribed his chemical medicines, induced a number of phyſicians to cultivate that new art; and in a ſhort time ſeveral valuable works appeared on the preparation of chemical medicines. Such are the works of Crollius, Schroder, Zwelfer, Glaſer, Tackenius, Lemery, &c.; as well as the pharmacopœiæ publiſhed by the principal faculties of medicine in Europe. About this time Glauber, a German chemiſt, rendered an important ſervice to his art, by examining the reſidues of operations, which had hitherto been always thrown aſide as uſeleſs, and diſtinguiſhed by the name of *caput mortuum*, or *terra damnata*. He diſcovered by this means the neutral ſalt which bears his name, and the ammoniacal vitriolic ſalt, and explained the chemical proceſſes neceſſary in preparing mineral acids, &c.

Several of thoſe who have contributed to the advancement of chemiſtry ſince the days of Paracelſus, were not fully convinced of the abſurdity of his wild notions. Among theſe were Caſſius, known for his precipitate of gold; Sir Kenelm Digby, who believed in the ſympathetic action of medicines; Libavius, who has communicated his name to a preparation of tin;

Van Helmont famous for his ſingular notions both in chemiſtry and medicine; and, laſtly, Borrichius, a Daniſh phyſician and chemiſt, who firſt diſcovered and made known to the world the poſſibility and the manner of inflaming oils with the nitrous acid, and who deſerves the gratitude and reſpect of the world for having bequeathed his library and chemical laboratory to the uſe of indigent ſtudents of medicine.

Alchemy was now oppoſed by two celebrated geniuſes, who were ſucceſsful in their attacks. The one, the celebrated Father Kircher the Jeſuit, to whom we are indebted for a noble work, intitled *Mundus Subterraneus;* the other, the learned Conringius.

V.

Riſe and Progreſs of philoſophical Chemiſtry, from the middle of the ſeventeenth to the middle of the eighteenth Century.

HITHERTO chemiſtry had never been treated in a philoſophical manner. The chemical arts had indeed been deſcribed, medical formulæ had been given, and the nature of metals painfully examined, in the hopes of making gold, or diſcovering an univerſal medicine: A chimera ſtill fondly believed by the ignorant and enthuſiaſtic! But nothing more had been done. A great number of chemical facts were known; but none had attempted to form them into a ſyſtem: And, as the celebrated Macquer has ingeniouſly obſerved, *though many branches of chemiſtry were known and practiſed, the ſcience itſelf was not yet in exiſtence.*

Towards the middle of the ſeventeenth century, James Barner, phyſician to the King of Poland, arranged the principal facts then known, in a methodical manner, accompanying them with obſervations, in his *Philoſophy of Chemiſtry*. The work of that learned author is the more valuable, on account of his being the firſt who attempted to form a complete ſyſtem of chemical knowledge, and ranked chemiſtry among the ſciences. Bohnius, profeſſor at Leipſic, wrote alſo a book on ſcientific chemiſtry, which was very favourably received by the world, and was long the only elementary book on the ſubject.

Joachim Beccher of Spires, a man of very conſiderable genius, phyſician to the Electors of Mentz and Bavaria, diſtinguiſhed himſelf ſo highly in this ſcience as to cauſe the names of the two laſt mentioned writers to be almoſt entirely forgotten. In his noble work, intitled *Phyſica ſubterranea*, he has collected all the chemical phenomena at that time known, and has deſcribed them with amazing accuracy. He has even foretold many of the diſcoveries which have been ſucceſſively made ſince he wrote; ſuch as the exiſtence of aeriform or gazeous ſubſtances; the poſſibility of reducing animal bones into a tranſparent glaſs, &c. A celebrated phyſician, whoſe name marks the commencement of a new and more illuſtrious æra in the annals of chemiſtry, has done him the honour of writing a commentary on his work. J. Erneſt Stahl, who was born with a natural fondneſs for chemiſtry, undertook to illuſtrate the doctrine of Beccher by a commentary. His favourite object, to which he more particularly directed his attention, was to demonſtrate the exiſtence of that inflammable earth which he denominated Phlogiſton. Not inferior to Beccher in genius, he excelled him in accuracy and method. His treatiſes on ſulphur and ſalts, together with that which is intitled *Trecenta Experimenta*, have acquired him immortal honour, and have ranked him among the firſt characters of the age in which he appeared.

Boerhaave, amid his various engagements, found leiſure to cultivate chemiſtry, and compoſed a very profound work on this ſcience, which has long been highly celebrated. The treatiſes on the four elements, particularly that on fire, which form a part of this work, are each of them maſterpieces, containing all that was at that time known on their particular ſubjects. He was alſo the firſt who attempted to analyſe vegetables; and to him we owe the ſpiritus rector, &c.

Stahl's theory has been generally adopted by ſucceeding chemiſts, and has acquired greater ſtability from the labours of the two illuſtrious brothers Meſſrs Rouelle, to whom we are chiefly indebted for the progreſs which chemiſtry has made in France, and whoſe loſs is ſeverely felt by the chemical world.

The illuſtrious Macquer, of whom death has now deprived the philoſophical world, contributed in a very ſignal manner to the advancement of the ſcience; and his valuable works are ſtill juſtly eſteemed, over all Europe, as the beſt guides to chemical knowledge. Beſide the important ſervices which he performed to the world, by publiſhing his Dictionary and Elements of Chemiſtry, his inquiries and diſcoveries concerning the nature of arſenic, Pruſſian blue, the dyeing of ſilks, clays for pottery, &c. might well immortalize his name, and intitle him to the gratitude of poſterity.

LIBRARY ROYAL ASIATIC

VI.

Pneumatic Chemiſtry: the preſent Time.

STAHL, being wholly engaged in demonſtrating the exiſtence of phlogiſton, and tracing it through all its combinations with other bodies, ſeems to have overlooked the influence of air in moſt of thoſe phenomena in which he aſcribes ſo much to the energy of the inflammable principle. Boyle and Hales had already ſhown the neceſſity of referring many chemical phenomena to the operation of that fluid. Boyle had taken notice of the difference of the appearances which the ſame chemical events exhibit in the open air and *in vacuo*. Hales had obtained from a variety of bodies a fluid which he took for air, but in which he obſerved a number of peculiar properties; ſuch as ſmell, inflammability, &c. according to the nature of the ſubſtances from which it was obtained. He was led to conſider air as the principle on which the conſiſtency and ſolidity of bodies depended.

Dr Prieſtley, by repeating a great part of Hales's experiments, diſcovered a number of fluids, which, though they have the appearance of air, yet differ from it in all their eſſential properties: and, in particular, from metallic calces he extracted a ſpecies much purer than atmoſpheric air.

M. Bayen, a chemiſt deſervedly celebrated for the accuracy of his reſearches, examined the calces of mercury, and found that they are reducible without phlogiſton, and that during the proceſs they emit an aëriform fluid in great abundance.

M. Lavoiſier, ſoon after this, diſcovered, and proved by a number of fine experiments, that in the proceſs of burning or calcination, a portion of the air always enters into combination with the body which is calcined or burnt. In conſequence of this diſcovery, he formed a ſect of chemiſts who agreed with him in doubting the exiſtence of *phlogiſton*, and aſcribed to the fixation or the diſengagement of air all thoſe phenomena which Stahl had referred to the ſeparation or the combination of *phlogiſton*. It muſt be granted, that this doctrine has been more fully demonſtrated than Stahl's; and that it agrees better with that accuracy and method which have of late been introduced into the ſtudy of natural philoſophy. In this light did it appear to the late M. Bucquet, who in his two or three laſt courſes of lectures ſeemed to give it the preference. The moſt prudent part on this occaſion certainly was, to wait till it could be determined by a greater number of facts, whether all the phenomena of chemiſtry might be explained by the theory of gaſes, without our having recourſe to *phlogiſton*. M. Macquer, ſenſible that a conſiderable revolution muſt neceſſary take place in the ſyſtem of chemiſtry in conſequence of theſe diſcoveries, but thinking it impoſſible to account for all the phenomena without admitting the preſence of an inflammable principle, ſubſtituted light in the room of *phlogiſton*; as the exiſtence of the latter had never been ſtrictly demonſtrated, while the influence of light on many chemical phenomena is a well known and undeniable fact.

Since the death of that celebrated chemiſt, the ſcience has been enriched with a variety of diſcoveries, all tending to confirm the new theory. The multitude of facts which I have been collecting during a period of twelve years, and the number of the experiments of other chemiſts, which, on a repetition of them, I have found to be attended with the ſame reſults, have finally convinced me of the juſtneſs of that theory, and have led me to conſider thoſe naturaliſts who ſtill continue to maintain, with more or leſs keenneſs, the exiſtence of *phlogiſton*, as either unſkilled in the ſcience, or incapable of accuracy in their experiments.

CHAP. III.

Concerning the Chemical Attractions or Affinities.

IN the firſt chapter it was obſerved, that the means uſed in performing chemical operations, which have been arranged under the two general heads of Analyſis and Syntheſis, are imitated from Nature, who employs them in her operations. To illuſtrate that truth, we ſhall here explain what is underſtood by the chemical affinities.

A perſon cannot even enter upon the ſtudy of nature, without taking notice of that wonderful mutual force by which all natural bodies are attracted towards each other. On this great and univerſal law, all thoſe phenomena depend which the philoſopher contemplates with curioſity, and which even the moſt ignorant of men cannot behold without admiration.

This force, by which indeed the order of the univerſe is maintained, actuates the moſt minute bodies as well as the moſt enormous maſſes of matter. But it acts by laws, either eſſentially different, or at leaſt differently modified, according to the maſs, conſiſtency, and diſtances, of the bodies ſubject to its influence. Without examining its effects on the planetary bodies, whoſe diſtances and motions it regulates; let us conſider in what manner it affects the different parts of the globe which we inhabit, that we may by this means diſcover its laws.

Natural philoſophy teaches, that when two ſolid bodies of the ſame kind come into contact, they adhere together with a degree of force proportioned to the extent of ſmoothneſs of the ſurfaces in contact. Thus, two planes of glaſs, or two ſections of a ball of metal, if preſſed together, unite with a degree of tenacity which renders a conſiderable effort neceſſary to ſeparate them. This force produces all the phenomena obſerved in chemiſtry. It becomes, therefore, an object of the higheſt importance to ſtudy all its laws, and inquire what variations it undergoes from diverſity of circumſtances.

The greater part of chemiſts have denominated this force *affinity* or *relation*; becauſe it has been thought to depend on an analogy or conformity of principles in the bodies between which it ſubſiſts. Bergman has given it the name of *chemical attraction*: and though its phenomena are different from thoſe of the planetary attraction firſt obſerved by Newton, yet, as both depend upon the ſame principle, we ſhall follow Bergman in the uſe of the name. Chemical attraction may take place between bodies of the ſame nature; or between bodies of different natures. Let us conſider it under theſe two points of view.

§ I. *Concerning the Attraction or Affinity that takes place between Bodies of the ſame Kind, or the affinity of Aggregation.*

WHEN two bodies of the ſame nature, for inſtance two globules of mercury, placed at a certain diſtance from each other, tend, by virtue of this force, to unite, and do actually enter into union, they form a ſphere greater in bulk, but preciſely the ſame in nature. In that event, therefore, this force affects only the phyſical, or obviouſly apparent qualities of bodies; it joins ſeparate portions of ſimilar matter; by confounding together ſeveral diſtinct maſſes, it forms a body of greater bulk, and unites a number of ſeparate parts into one *whole*. It is denominated the *attraction or affinity of aggregation*, in order to diſtinguiſh it from that which takes place between bodies of different natures. It produces an aggregate in which the phyſical qualities of the bodies united undergo a new modification, without any ſenſible change being produced in their chemical qualities. The *aggregate* is nothing more than a coherent body, the parts of which are retained in union by the force of aggregation. It muſt be diſtinguiſhed from the maſs called an *heap*; for though an heap conſiſt of parts all of a ſimilar nature, yet thoſe parts are diſpoſed looſely, and without coherence. It is likewiſe to be diſtinguiſhed from a *mixture*; which conſiſts of a quantity of diſſimilar particles blended together without adherence. This may be farther explained by a familiar example: Flowers of ſulphur, or ſulphur in powder, whoſe parts have no adheſion, and may be ſeparated by the ſlighteſt effort, compoſe an heap, the parts of which are not affected by the affinity of aggregation. This mixed with another heap, with one for inſtance conſiſting of nitre in powder, gives what is called *a mixture by confuſion*. But if, by the help of fuſion and cooling, you ſubject this heap to the power of aggregation, the molecules or integrant parts of the ſulphur will then be drawn towards each other during its liquefaction, and will mix and unite in ſuch a manner as to form, when cooled, an uniform maſs or ſolid, which will be a true aggregate.

The force or affinity of aggregation exiſts in various degrees, which are meaſurable by the effort neceſſary to ſeparate the integrant parts of any aggregate body. We ſhall diſtinguiſh aggregates into four kinds, under which all the bodies in nature may be arranged.

1. The firſt is the *hard or ſolid aggregate*, in which the integrant parts are united by a very conſiderable force, and cannot be ſeparated without great exertion. This genus comprehends many ſpecies or degrees, from the hardneſs of the precious ſtones and of rock-cryſtal, to the yielding contexture of the ſofteſt wood. Its peculiar characteriſtic is to form a maſs, the conſtituent parts of which cannot ſuffer any diſcernible motion without being divided.

2. Bodies whoſe conſtituent parts may be eaſily moved backwards and forwards, ſo as to change their relative ſituation, without being ſeparated, belong to *the ſoft aggregate*. Leſs force is requiſite to maintain the coheſion of a ſoft body than to preſerve the conſiſtency of a ſolid aggregate; and leſs reaction to deſtroy it.

3. *The fluid aggregate*. Its integrant parts are ſo ſlightly united, that the gentleſt effort is ſufficient not only to change their relative ſituation, but even to didivide them into diſtinct globules.

4. Laſtly, the *aëriform aggregate*, the tenuity of whoſe integrant particles renders them imperceptible, and in which the affinity of aggregation is the leaſt

poſſible. The air of the atmoſphere affords an example of this.

Theſe four kinds of aggregate are, properly ſpeaking, but different degrees of the ſame force: but it is abſolutely neceſſary to diſtinguiſh them accurately from one another; becauſe they have an important influence on the operations and phenomena of chemiſtry, which is diverſified according to their differences: yet it may be proved in the moſt ſatisfactory manner, that they are only ſo many different degrees of the ſame force; for many bodies are capable of aſſuming each of theſe four ſtates ſucceſſively. Water, in the form of ice, is a ſolid aggregate; its hardneſs is greater in proportion as its temperature is lower; when expoſed to the temperature of 32° Fahrenheit, it aſſumes a kind of ſoftneſs* before paſſing into a fluid ſtate. Its exiſtence in this laſt ſtate is univerſally known: and philoſophers have calculated what degree of expanſive force is neceſſary to reduce it to vapour; in which ſtate it becomes an aëriform aggregate. Metals, greaſe, concrete oils, wax, &c. may be in the ſame manner made to paſs through theſe ſeveral ſtates of aggregation.

The more particularly any perſon is acquainted with the laws of chemical attraction, ſo much the more will he be convinced of the importance of diſtinguiſhing between theſe ſeveral kinds of aggregation, and eſtimating each of them aright. Accurate ideas concerning each of them are eſſentially neceſſary to enable us to compare this with the ſecond ſpecies of chemical attraction, which will come next to be examined.

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* A doubt expreſſed by the tranſlator of the ſecond edition, induced me to repeat this experiment; and I found that M. Fourcroy had by no means miſrepreſented the fact.—H.

As theſe two kinds of affinity, though they appear to depend on the ſame cauſe or principle, yet in all the phenomena of chemiſtry ſeem to act in direct oppoſition to each other (for it may even be inferred from facts which ſhall be related, that they are in the inverſe ratio of each other), it is abſolutely neceſſary for the chemiſt to weaken or deſtroy the one, when he wiſhes to effect any operation by means of the other. Now, the attractive force of which we have been ſpeaking, is almoſt always that which he has occaſion to diminiſh; and it likewiſe admits of various modifications by the power of art.

All that is neceſſary to deſtroy or weaken the affinity of aggregation, is, to oppoſe to the coheſion of the aggregate an external force more than ſufficient to counterbalance that which preſerves the union of its component parts; and the external force applied muſt therefore be proportioned to the coheſion of the parts. This is the great law to be always obſerved in the preparatory operations; the ſole purpoſe of which is to deſtroy the affinity of aggregation. Pulverization, grinding, raſping, filing, and cutting, are ſo many means for counteracting the coheſion of bodies and dividing their conſtituent parts. Heat and evaporation produce the ſame effects on fluids, and on thoſe ſolids which are ſuſceptible of dilatation or fuſion. But theſe laſt mentioned operations being effected by heat, come properly under the ſecond ſpecies of chemical attraction; as does alſo the ſolution of bodies by water.

As art can apply a great variety of means to counteract, and even deſtroy the fore of aggregation; ſo it likewiſe affords others to reſtore it, and cauſe it to act with all its former energy. All the manipulations which it employs for this purpoſe, conſiſt in placing the bodies, whoſe force of aggregation is to be reſtored, in ſuch a ſtate of diviſion and fluidity, that their particles may be at liberty to obey the power of attraction, by applying to each other thoſe of their ſurfaces which are beſt adapted to unite; and they thus form a new aggregate, which, in regularity of figure and cohesive force, is generally equal, and ſometimes ſuperior, to natural aggregates of the ſame kind. We may take this opportunity to obſerve, that all aggregate bodies may be divided by their figure into two claſſes, Regular and Irregular. Every body in nature appears under the one or the other of theſe two forms; and art, which always emulates, and ſometimes even rivals, nature, can produce at pleaſure a regular or an irregular aggregate. All ſubſtances capable of paſſing through the ſeveral ſtates of aggregation above enumerated, but more eſpecially ſalts and metals, may be ſo managed during the proceſs by which they are reduced from a fluid to a ſolid ſtate, as to aſſume the form either of an irregular maſs, or of a body with regular lines, angles, and ſurfaces, which is called a cryſtal. The firſt form is obtained by keeping the particles of the fluid body, whether its fluidity may have been occaſioned by fire, or water, very near to each other; and cauſing the liquefaction to ceaſe ſuddenly, ſo that they may come into contact all at once, and the affinity of aggregation may cauſe them to unite into one ſolid maſs. But, on the contrary, to produce cryſtalliſation, it is neceſſary to keep the parts of the body which you wiſh to bring into that ſtate, at as great a diſtance as poſſible from one another, that they may remain for ſome time in a kind of equilibrium, before coming into union, and may preſent to each other ſuch of their ſurfaces as are beſt adapted to unite. From this it appears, that cryſtalliſation is entirely owing to the affinity of aggregation; and if the phenomena of cryſtalliſation be obſerved with a proper degree of attention, they will afford an idea of the manner in which the affinity of aggregation acts. For this purpoſe it is mentioned here: it will be more particularly explained under ſeveral future articles of this work.

§ II. *Concerning that Species of Chemical Attraction which unites particles of different Natures; or the Affinity of Compoſition.*

When two bodies differing in nature have a tendency to unite, they enter into combination by virtue of a power ſomewhat different from that which we have been conſidering: it has been denominated *the affinity of compoſition;* but may be with more propriety named *the attraction of compoſition.* This ſpecies of attraction or affinity is of ſtill greater importance than the former, as it acts in all chemical operations, and none of theſe can be explained without it. The exiſtence of this power has been always known; but it was not obſerved with the attention which it juſtly merits, till ſuch time as it appeared to affect the practice no leſs than the theory of the ſcience of which we are treating. A knowledge of this affinity is eſſentially neceſſary to direct the practitioner who purſues a train of experiments, as well as the philoſopher who collects and compares facts. This is the compaſs by which both muſt ſteer; and it may be affirmed, that whoever is well acquainted with the laws of chemical attraction, is acquainted with the extent and ſublimity of the ſcience.

Convinced of this truth, we ſhall here make it our buſineſs, firſt, to exhibit faithfully all the facts which can ſerve to illuſtrate the nature of this affinity; and, next, to give an account of thoſe hypotheſes which have been formed to explain its cauſe.

Obſervation, the parent not only of chemiſtry but of all experimental ſcience, has ſhown, that the attraction, or affinity of compoſition, preſents certain invariable phenomena; which may be conſidered as laws eſtabliſhed by nature, and which can eſcape the obſervation of none but ſuch as are incapable of examining them with due attention. Theſe laws, founded on a vaſt variety of well-eſtabliſhed facts, may be reduced to eight; which are as follows,

I. *Firſt Law of the Attraction of Compoſition.*

The attraction, or affinity of compoſition, cannot act but between bodies of different natures.

This firſt law is invariable, and admits of no exceptions. That two bodies may combine, and form a compound, it is indiſpenſibly neceſſary for them to be different in kind. Join two bodies of the ſame nature, and you form only an aggregate, of which the bulk and extent are enlarged, but its eſſential properties remain unaltered; and their union is occaſioned and preſerved by the affinity of aggregation, conformably to the explanation already given of the nature of that affinity. Thus, two pieces of wax, roſin, or ſulphur, may be united by the action of heat; and this inſtance is ſufficient to explain the difference between aggregation and compoſition.

This law holds ſo invariably, that the attraction of compoſition is never ſtronger than when the bodies between which it acts are, in nature, the moſt eſſentially different from one another. Thus acid ſalts and alkalis, though the properties of the one are directly oppoſite to thoſe of the other, enter into the moſt intimate mutual combination, and form the moſt perfect compound. The ſame oppoſition ſubſiſts between the properties of alkalis and ſulphur, of acid ſalts and oil, of acids and metals, of water and ſpirit of wine, &c.; all which ſubſtances have a ſtrong tendency to mutual union.

It is the more neceſſary for us to gain an accurate knowledge of this great law of the affinity of compoſition, becauſe a number of chemiſts, with Stahl at their head, have laboured to prove, that bodies never enter into combination, but in conſequence of a certain relation, or reſemblance between their properties: an opinion to which no perſon will agree who knows the full extent of this primary law. When reading the reaſonings even of the moſt eminent chemiſts on this ſubject, we cannot avoid obſerving, that the relations which they labour to point out between thoſe ſubſtances which have the ſtrongeſt tendency to mutual union, appear always extremely remote; and that, by the ſame means, reſemblances might be eaſily found out between bodies the moſt diſſimilar. It is eaſy to ſee, however, that theſe ingenious men have propoſed this theory, merely from a deſire to ſimplify and illuſtrate the doctrine of chemical-attractions: and thoſe who are ſenſible of the difficulty of eſtabliſhing ſyſtems in any of the departments of human knowledge, will always conſider them as entitled to the gratitude of every friend of ſcience. Their labours have not been without their uſe, as they have collected a number of facts, and pointed out their connection. But a regard to truth, which it becomes us to prefer to every other conſideration, obliges us to confeſs our ignorance of the cauſe of this important phenomenon, inſtead of referring it to an analogy, the exiſtence of which is inconſiſtent with thoſe ideas of the properties of bodies which we derive from experiment.

II. *Second Law of the Attraction of Compoſition.*

The attraction of compoſition acts only between the minuteſt particles of bodies.

In order to form a juſt idea of the nature of this law, it is neceſſary for us to diſtinguiſh chemical from phyſical ſubjects. Theſe laſt are bodies whoſe external qualities, ſuch as weight, bulk, ſurface, extent, and figure, are perceptible to our ſenſes, and may be eſtimated by their effects upon them. Aggregates are the bodies whoſe qualities are obſerved and compared by the naturaliſt. Chemical ſubjects, again, are ſubſtances which have loſt their aggregation; and which, of conſequence, no longer preſent to the ſenſes the phyſical properties of aggregates. They are minute particles, the extent of which cannot be meaſured, nor their bulk or form diſtinguiſhed It is not till after bodies have been reduced to this ſtate of tenuity by the ſeveral preparatory operations above-mentioned, that they become ſubject to the affinity of of compoſition; and the chemiſt cannot cauſe them to enter into combination, without preſenting them to one another in a ſtate of diviſion. This force ſeems to actuate none but the minuteſt particles of bodies: and in this manner does the attraction of compoſition appear to differ from that which acts between large maſſes of matter. The difference is ſtill more ſtriking when we conſider the conſtant oppoſition between the attraction of aggregation and that of compoſition. This oppoſition is ſo invariable, that we may even venture to advance it as a chemical axiom, that the attraction of combination is in the inverſe ratio of that of aggregation; theſe two forces being always in oppoſition, and forming a kind of counterpoiſe to each other. The attraction of aggregation always reſiſts the combination of different bodies; where it acts with the greateſt force, they have ſcarce any tendency to mutual union; and again ſuch ſubſtances as are the leaſt under the influence of the force of aggregation, have a ſtrong tendency to combine with others. The various kinds of *gas*, or air, for inſtance, of all known ſubſtances are the leaſt under the influence of the force of aggregation; and of them there are many whoſe tendency to combination is ſo ſtrong, that they combine with the greateſt facility with almoſt any natural body. Yet we ſhall afterwards ſee that this happens only when the heat which enters into the compoſition of elaſtic fluids is but ſlightly combined with a baſe; and that the aëriform ſtate often occaſions a contrary tendency; as for inſtance, in pure air.

III. *Third Law of the Attraction of Compoſition.*

The attraction of compoſition can unite more bodies than two.

THIS law of chemical attraction is one of thoſe which have been eſtabliſhed by the feweſt obſervations; and we are ſtill but very imperfectly aquainted with its extent. We are acquainted with a vaſt variety of thoſe combinations which are produced by the union of two bodies; with a few which are formed by the union of three bodies; but we know of ſcarce any inſtances in which four different bodies have an equal tendency to enter into mutual combination, and remain in this ſtate. Metals are the only bodies that are known to be capable of this laſt ſpecies of combination; and of which two, three, or four, may be effectually blended together. It is highly probable that there are in nature combinations made up of more than four bodies, of ſix or eight, for inſtance; but with ſuch we are hitherto unacquainted. The reaſon why ſo little progreſs has been made in the ſtudy of this law, ſhall be explained when we come to treat of the eighth law of the affinity of compoſition. The number of the ſubſtances of which any compoſition conſiſts is denoted by ſaying, the affinity of one, two, three, or four bodies, and ſo on. The rapid progreſs which chemiſtry has of late begun to make, the multiplicity of its reſearches, the variety of the objects to which theſe are directed, and the ſcrupulous accuracy of obſervation with which they are conducted, afford us reaſon to hope that thoſe affinities which are named *complex* will ſoon be better known.

IV. *Fourth Law of the Affinity of Compoſition.*

That the affinity of compoſition may take place between two bodies, at leaſt one of the two muſt be in a fluid ſtate.

This law has been long known to chemiſts, and has been long expreſſed in this axiom, *Corpora non agunt, niſi ſint ſoluta.* Uniform and accurate obſervation has ſhown that two ſolid ſubſtances can never enter into mutual combination. Even bodies which have the ſtrongeſt tendency to unite, cannot be brought into union till either the one or the other of them be reduced to a fluid aggregate. Bodies enter into combination with more or leſs facility, according as they are more or leſs in a ſtate of fluidity, and conſequently poſſeſs more or leſs aggregative force: and therefore no two bodies enter into combination with ſuch rapidity as any two of the ſaline aëriform fluids; for inſtance the muriatic acid gas and the alkaline gas.

Though no two ſolid bodies can enter into combination with each other; yet in ſome inſtances dry ſubſtances, reduced into a fine powder, re-act upon each other with ſo much energy, as to unite and form a new compound. Thus I have diſcovered that cauſtic fixed alkali, when reduced by trituration, unites in a cold dry ſtate with ſulphur, antimony, and kermes, as I ſhall elſewhere more particularly relate: but in this inſtance, the reduction of the bodies into their moſt minute particles by pulverization, and the moiſture of the atmoſphere attracted by the ſalt, which ſoon deliquates, have a conſiderable ſhare in effecting the combination;

and indeed bring this phenomenon under the law, which we are now engaged in examining.

But it is not always neceſſary that the bodies which you wiſh to combine be both fluids; it is enough that one of them be in that ſtate. When they unite, a phenomenon takes place, to which chemiſts have given the name of *ſolution*. It conſiſts in the attenuation, diviſion, and entire deſtruction of the ſolid body in contact with the fluid. The cauſe of this phenomenon is, that the attraction of combination between two ſubſtances, one of which is a liquid, the other a ſolid, ſuch as the ſulphureous acid, and a bit of calcareous ſpar, is ſtronger than the aggregative force which preſerves the particles of the ſolid in excluſive union with one another. Now ſince, by the third law, this ſpecies of attraction cannot act but on the moſt minute particles of bodies, the ſpar muſt neceſſarily loſe its aggregation, and be reduced into very ſmall particles, in order that it may combine with the *ſulphuric* acid, and form *calcareous ſulfate*. Formerly, chemiſts always diſtinguiſhed between the body which effected and that which ſuffered the act of ſolution; the former was the fluid, the latter the ſolid. But modern chemiſts refuſe to admit this diſtinction, as it ſuppoſes a force in the fluid ſuperior to what exiſts in the ſolid aggregate. M. Gellert was the firſt who obſerved that the two bodies contribute equally to the act of ſolution; and that in the above inſtance, the vitriolic acid could not deſtroy the aggregation of the ſpar, had not the ſpar a tendency to unite with the ſulphuric acid no leſs ſtrong than that of the acid to combine with it. The name *ſolvent*, therefore, given at preſent to fluids, is not ſtrictly chemical, as it conveys only the idea of a mechanical operation; and it were better to lay it aſide. But ſince it has been unluckily introduced, the ſtudent of chemiſtry muſt always remember, that when one body is ſaid to diſſolve another, no more is meant than that the former is in a fluid ſtate, and that the fluid can never poſſeſs greater activity or energy than the ſolid; but the ſolid may rather be conſidered as poſſeſſing theſe qualities in a ſuperior degree, ſince its tendency to combination is ſo powerful as to overcome its aggregative force.

The falſe idea of ſolution which has prevailed till of late, aroſe no doubt from the mechanical theory by which ſome philoſophical chemiſts have ſought to explain this operation of nature. This theory, which appears in every page of Lemery's chemiſtry, conſiſts in conſidering the ſolvent, an acid, for inſtance, as an aſſemblage of very acute points, and the body to be diſſolved, as containing a vaſt number of pores, into which the points of the acid inſert themſelves, ſo as to disjoin the particles of the body, and reduce them to that ſtate of diviſion in which the aggregate diſappears. To mention this opinion is, at preſent, all that is neceſſary to ſhow its abſurdity and inconſiſtency with thoſe laws which accurate obſervation has eſtabliſhed in the experimental ſciences.

V. *Fifth Law of the Attraction of Compoſition.*

When two or more bodies are combined by this affinity, their temperature ſuffers a change at the inſtant of their union.

THIS phenomenon ſo invariably attends all the combinations effected by art, that we cannot help conſidering it as one of the laws of the attraction of compoſition. The temperature of bodies may be altered in two ways; new combinations ſometimes produce cold, ſometimes heat. The latter is oftener produced than the former: but as cold is certainly produced in ſeveral ſynthetic operations, we have thought proper to expreſs this phenomenon by the general term, Change of temperature.

It may be objected, that in certain ſolutions or combinations which are ſlowly effected, no change of temperature is perceived: But we would deſire perſons who are diſpoſed to offer ſuch an objection, to immerſe a good thermometer into thoſe ſolutions, and they will not fail to be convinced that a change of temperature is produced. It appears from ſome valuable obſervations by M. Baumé, which ſhall be elſewhere more particularly mentioned, that this phenomenon is occaſioned by the change of aggregation, which the bodies entering into combination undergo as they paſs from a ſolid to a fluid ſtate. But as that change is produced by the action of the affinity of compoſition, both the one and the other evidently depend on this principle.

Macquer has given it as his opinion, that the variations of the temperature of bodies entering into combination, are occaſioned by the motion of their component particles: but though we ſhould admit this as an happy account of the cauſe of the heat produced in new combinations, ſtill the cold which takes place in ſome of them remains unexplained. Several modern chemiſts, particularly Scheele and Bergman, conſider heat as a diſtinct body, acting a principal part in all chemical combinations; and aſſert, that change of temperature ariſes from the abſorption or diſengagement of this body. This theory affords a good explanation of the cauſe of that change of temperature which takes place when a new combination is produced.

VI. *Sixth Law of the Attraction of Compoſition.*

Two or more bodies united by the attraction of compoſition, form a ſubſtance, the properties of which are different from thoſe which each of the bodies poſſeſſed before their union.

It is of importance to eſtabliſh the exiſtence of this law; becauſe many celebrated chemiſts of the preſent age, have entertained opinions concerning the properties of compounds, which to us appear inconſiſtent with a great number of facts, and are directly contradictory to what we here offer as one of the principal phenomena of the affinity of compoſition.

Stahl and his followers, whoſe genius has, in other inſtances, rendered ſo many important ſervices to chemiſtry, have aſſerted, that compounds always partake of the properties of thoſe bodies of which they are compounded, and poſſeſs a kind of middle nature between their principles. They have even carried this notion ſo far as to perſuade themſelves, that it is poſſible to determine the peculiar properties of any principles, by examining the compound formed by their union. Thus, Stahl pronounced ſalts to be a compound of earth and water, becauſe he thought he could diſtinguiſh their properties to be intermediate between the properties of theſe two ſubſtances. As we are to examine this leading doctrine when we come to conſider the general nature of ſalts, it would be improper to enlarge upon it here: We ſhall only obſerve, that thoſe chemiſts who have adopted this opinion of Stahl's, have not been happier than he in the proofs which they have adduced to eſtabliſh it; and that the intermediate properties which they have diſcovered in compound bodies, have always a very remote relation to thoſe of their principles, as ſhall be clearly ſhown to be the caſe, even in the chief inſtances adduced by Stahl. I muſt even acknowledge, that what firſt induced M. Bucquet and myſelf to examine this theory with particular attention, and finally to adopt one directly oppoſite to it, was our obſerving with what difficulty, and how ineffectually, Stahl had laboured to eſtabliſh it in his works. All that is neceſſary to prove the exiſtence of this law, for which we reject the theory of Stahl, is, to produce ſome inſtances in which the properties of compounds are totally different from thoſe of either of their principles. But the phenomena of all chemical combinations come under this deſcription; not one but affords an inſtance in behalf of that truth which we wiſh to eſtabliſh.

In order to ſhow, 1*ſt*, That bodies which enter into combination loſe their original properties; 2*dly*, That they acquire new properties totally different from thoſe which they before poſſeſſed; let us ſelect ſome properties of which the variations may be eaſily diſtinguiſhed. Taſte is often a very eminent property in two diſtinct bodies, which when united are almoſt inſipid in compariſon of their former ſapidity. *Sulfate of potaſh*, or vitriolated tartar, which is produced by the combination of two potent cauſtics, the ſulphuric, or vitriolic acid, and pure *potaſh*, has only a bitter taſte; which is by no means an intermediate between the cauſtic poignancies of theſe two ſalts. Again, two bodies with little or no taſte, often acquire by combination a very ſtrong taſte; a few grains of the *oxigenated muriatic acid*, or a few grains of mercury given in a glaſs of water, can produce no bad effects on the animal œconomy; whereas, if combined ſo as to form the *oxigenated mercurial muriate*, or corroſive ſublimate, and adminiſtered in the ſame manner, they have a moſt pungent taſte, and produce the moſt fatal effects on the human conſtitution.

Bodies entering into combination are no leſs liable to change of form. Two ſubſtances, neither of which is by itſelf ſuſceptible of cryſtallization, often aſſume a regular form when combined together: thus *muriatic acid gas*, and *ammoniac* or alkaline gas when they enter into combination, form cryſtals of *ammoniacal muriate*. In other inſtances, the form ſuffers only a ſlight change of modification; as in the combination of certain neutral ſalts in the union of ſulphur with metals, and in alloyed metals; which laſt have been obſerved by M. l'Abbé Mongez to afford cryſtals ſomewhat different from thoſe of pure metals. *Laſtly*, Bodies that are, in a ſimple ſtate, highly ſuſceptible of cryſtallization, loſe this property when combined with other bodies. This happens to all metals when united with the *oxigenous* principle; and to ſome of them when combined with acids, &c. *.

The conſiſtency of bodies is alſo affected by their combination; the conſiſtency of a compound being almoſt always different from that of either of the ſimple bodies of which it is compoſed. Thus, two fluids often produce a ſolid by their combination; for inſtance, the ſulphuric acid united with a ſolution of potaſh. And again, a fluid often reſults from the combination of two ſolids; as from a combination of neutral ſalts with ice, and from the mixture of an amalgam of lead with an amalgam of biſmuth. But the quality which ſuffers the moſt frequent alterations in the combination of bodies is colour. Sometimes it is loſt: thus the coloured muriatic acid, combined with a metal, becomes white. But it oftener happens, that two bodies deſtitute of colour, aſſume when united either a fainter or ſtronger colour, as when iron or copper are diſſolved in almoſt any of the acids, and when the calces of lead, mercury, or almoſt any other metal, are united with oxygen.

Many bodies, which in a ſimple ſtate, are ſtrongly odoriferous, become inodorous when brought into combination; as for inſtance, muriatic acid gas and ammoniac or alkaline gas, which in a ſimple ſtate have a ſtrong ſuffocating ſmell, form in combination ammoniacal

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* We cannot avoid making uſe of terms and denominations not yet explained. But the reader may have recourſe to the table ſubjoined at the end of the laſt volume, and to the beginning of our account of the ſeveral articles to which ſuch names belong, for an explanation of them. This inconvenience, though it may perplex the beginner, cannot be otherwiſe obviated.

cal muriate, a neutral ſalt that has ſcarce any ſmell. Again, from the union of two indorous bodies, there often reſults a ſtrong-ſmelling compound; ſulphur and fixed alkali, each of which is in a ſimple ſtate almoſt deſtitute of ſmell, form, when united, liver of ſulphur, or *ſulphure*, a ſubſtance which in a moiſt ſtate is extremely fetid.

The fuſibility of bodies is ſubject to the ſame changes. Two ſubſtances, not ſuſceptible of fuſion, or which cannot be reduced to that ſtate without the greateſt difficulty, when combined acquire the property of fuſibility in an high degree. Combine ſulphur with any of the metals, and you will have a ſtriking inſtance of the truth of this aſſertion. A variety of other facts, beſide thoſe which have been here adduced, concur to eſtabliſh this law in contradiction to the theory of Stahl.

VII. *Seventh Law of the Attraction of Compoſition.*

The attraction of compoſition is meaſurable by the difficulty of deſtroying the combination formed between two or more bodies.

Chemists know how to ſeparate bodies in union, however ſtrong their natural attraction or adherence; but the means which they employ for this purpoſe are more or leſs eaſy, more or leſs complex. It has been uniformly obſerved, that in proportion as a compound is more or leſs perfect, its component parts are ſeparated with more or leſs difficulty: And the degrees of the difficulty with which any two ſubſtances are ſeparated, may be therefore conſidered as in direct proportion to the degrees of the attraction by which they mutually adhere; from the one we may form a juſt eſtimate of the other.

We conſider it as particularly neceſſary to inſiſt on this law, becauſe beginners are not to fall into miſtakes in eſtimating the differences of the attraction which unites the principles of different combinations. From the rapidity with which ſome ſubſtances combine, we are ready to imagine that their mutual attraction muſt be very conſiderable. But long experience ſhows that this eagerneſs to enter into combination, inſtead of indicating a perfect compoſition, is rather a proof that the attraction between the bodies is extremely weak, and can produce but a very imperfect compound. In order, therefore, to determine accurately the degree of affinity with which bodies unite and remain in union, we muſt conſider the eaſe or difficulty with which they are ſeparated. This will be farther explained by an examination of the eighth and laſt law of this ſpecies of chemical attraction.

VIII. *Eighth Law of the Attraction of Compoſition.*

Bodies have not all the ſame degree of chemical attraction with regard to one another; and the degrees of this force, ſubſiſting between different bodies may be determined by obſervation.

Natural bodies have not uniformly the ſame tendency to mutual combination. There are even ſome bodies which abſolutely refuſe to unite, or between which at leaſt art cannot effect a direct combination; ſuch as iron and mercury, water and oil, &c. though it is not true that theſe bodies have no mutual attraction. Others require long time and much pains to bring them into combination.

But the moſt important circumſtance of this variety of chemical attraction is, that ſince various bodies are united with various degrees of force, we may acquire ſuch an accurate knowledge of the particular degree of force which unites any two bodies, as to effect a ſeparation between them at pleaſure. Bergman has contrived the name *elective attractions*, to indicate that there is a kind of mutual choice between thoſe bodies, which in order to combine with one another, ſeparate themſelves from thoſe other ſubſtances with which they were before united, and entirely forſake their former ſtate. This decompoſition is even the grandeſt effect of the chemical art: by this the chemiſt is often able to perform what appears altogether miraculous to perſons unacquainted with the principles on which he proceeds. To comprehend the nature of this decompoſition, let us ſuppoſe two bodies to be united with a force equal to four; as for inſtance, an acid and an *oxide*, or metallic calx: Let us bring a third body, ſuch as an alkali, which has an affinity with the acid equal to five or ſix, into contact with this compound; the conſequence will be, that the alkali, whoſe tendency to combine with the acid is greater than that of the acid to remain in union with the metallic *oxide*, will deſert the latter in order to combine with the former. This is preciſely the reſult of ſuch a mixture, the metallic *oxide* appears in a ſeparate ſtate, and a new combination is formed, conſiſting of the acid and the alkali. This decompoſition is commonly known by the name of *precipitation;* becauſe the ſubſtance ſeparated generally ſinks to the bottom of the fluid compound.

The ſubſtance that ſinks to the bottom of the veſſel in which this operation is performed, is named a *precipitate.* The ſubſtance by the addition of which the phenomenon is produced, is denominated the *precipitant.* There are four different kinds of precipitates. *A true precipitate* is formed, when the ſubſtance which ſinks to the bottom is one of the principles of the compound decompoſed by the addition of the new body. When ſulfate of lime, which is a combination of lime and the ſulphuric acid, is decompoſed by means of potaſh, which ſubſtance has a greater affinity with the acid than with lime, the lime being ſeparated falls to the bottom, and conſtitutes a true precipitate. A *falſe precipitate* is produced, when the new combination of the' precipitant with one of the two ſimple bodies of the compound which it has decompoſed, falls to the bottom on account of its inſolubility, while the ſeparate body remains in a ſtate of ſolution. When *mercurial nitrate* is decompoſed by the muriatic acid, with which the oxide of mercury has a ſtronger affinity than it has with the *nitric acid,* the new combination of mercury with the muriatic acid ſinks to the bottom of the mixture, forming a falſe precipitate, above which the nitric acid remains diſſolved in the water. This phenomenon depends entirely, as ſhall be elſewhere ſhown, on the different degrees of the ſolubility of the different ſubſtances.

We cannot avoid obſerving, in this ſecond order of precipitates, an error of denomination which may tend to miſlead beginners. For, if this name be given to the ſubſtance ſeparated from the compound by the precipitant, it cannot with any propriety be applied to the new combination then formed. But though we ſhould even confine the term *precipitate* to denote the ſubſtance ſeparated by the precipitant, it might ſtill occaſion miſtakes; as it happens in many caſes that the inſulated ſubſtance, inſtead of ſinking, riſes and is volatilized. Thus, when the combination of the muriatic acid with volatile ammoniac or alkali, known by the name of ammoniacal muriate, is decompoſed by quicklime, with which the acid has a greater affinity than with volatile alkali, the alkali evaporates, and the mixture affords no appearance of any precipitate.

In order to produce theſe precipitates, it is neceſſary that the ſubſtances be in a liquid ſtate: The proceſs is then called precipitation effected in the humid way, to diſtinguiſh it from that which is accompliſhed by the action of fire, or in the dry way, either by means of fuſion or diſtillation; which operations ſhall be hereafter particularly explained.

Modern chemiſts have likewiſe taken notice of two other ſpecies of precipitate; the diſtinction between which is much more juſt and uſeful than that between the preceding. Theſe are *pure precipitates* and *impure precipitates*. The firſt comprehend all bodies which, after their ſeparation from thoſe compounds into which they entered, exhibit all their original properties, without appearing to have ſuffered any alteration, in conſequence either of exiſting in a compound ſtate, or of being expoſed to the act of decompoſition. The precipitates of this ſpecies are very numerous, but the impure precipitates ſtill more ſo.

In order that precipitates may be obtained very pure, it is requiſite that they ſhould have ſuffered no alteration by the action of the bodies with which they were combined before their precipitation; and that there ſubſiſt no affinity between them and the ſubſtance employed to precipitate them. For inſtance, when *alcohol*, or ſpirit of wine, is poured into a ſolution of ſulphate of potaſh, the ſpirit of wine having a ſtronger affinity with the water than the water has with the ſalt, the latter is left in a ſeparate ſtate, and becomes a pure precipitate, becauſe it has ſuffered no alteration from the water, and has not the moſt diſtant affinity with the alkohol. But when two bodies by combination have produced mutual alterations on each other, as happens in the combination of acids with metals, the third body, ſuch as an alkaline ſalt, employed to effect a ſeparation between them, will give the metal in a ſtate very different from its original character, and will thus produce an impure precipitate. The ſame reſult takes place when the precipitant has any tendency to unite with the precipitate: thus, in the above-mentioned inſtance of a metallic ſolution decompoſed by an alkali, part of the alkali entering into combination with the metallic oxide renders it an impure precipitate. Theſe two cauſes of the impurity of precipitates are almoſt always found to act together. We can ſometimes diſtinguiſh at once whether a precipitate be pure or impure, by adding a much greater quantity of the precipitating body than is neceſſary to decompoſe the compound. This extraordinary quantity then enables the precipitant to combine with the precipitate, if there be any affinity between them, and diſſolves the latter ſo entirely as to make it diſappear. If a quantity of volatile alkali or ammoniac be poured upon a ſolution of copper with the nitric acid, the copper is precipitated in the form of light blue flakes. The colour of this precipitate, ſo very different from the natural brilliancy of copper, ſhows it at once to be an impure precipitate: If we add more ammoniac, this will ſtill more plainly appear. The blue flakes are again diſſolved by the ſalt, the fluid becomes gradually homogeneous and tranſparent, and aſſumes a very fine deep blue colour; a ſure proof of the combination of the oxide of copper with the alkaline ſalt.

For our preſent accurate knowledge of theſe impure precipitates, which occur much more frequently than the pure, we are indebted to the reſearches of M. Bayen, concerning the decompoſition of mercurial ſolutions by alkalis, and the ſtate of the mercury precipitated in this operation.

It is now eaſy to underſtand the theory of the decompoſition of compounds of two bodies by means of a third brought into contact with them: they all depend upon ſimple elective attractions.

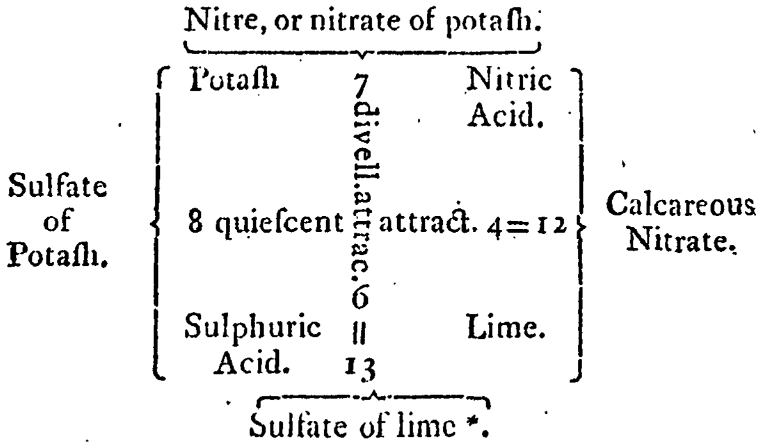
But beginners will find more difficulty in acquiring a diſtinct idea of that complicated phenomenon to which chemiſts have given the name of *double elective attraction.* It often happens that a compound of two bodies cannot be deſtroyed by a third or fourth body individually; while, if a compound of the two laſt be brought into contact with the firſt compound, both compounds are inſtantly decompoſed. An example will make this better underſtood: Sulphate of potaſh, or a combination of the ſulphuric acid with potaſh, cannot be decompoſed by either quicklime or the cold nitric acid individually; but pour into a ſolution of the former neutral ſalt a proper quantity of the *calcareous nitrate,* formed by the union of the nitric acid with quicklime, the two combinations will be mutually decompoſed; the nitric acid uniting with the potaſh to form common nitre, while the ſulphuric acid uniting with the lime, forms ſulphate of lime; which being leſs liable to ſolution than the nitre, is therefore precipitated. This affinity may poſſibly appear ſtrange and unaccountable; but it may be explained in the following manner: The ſulphuric acid cannot be ſeparated from potaſh, either by lime or by the nitric acid, becauſe it has a ſtronger affinity with that alkaline ſubſtance than either of the two latter bodies has with it or with the alkali. But when you preſent to the ſulfate of potaſh a compound of the nitric acid with lime, the nitric acid immediately exerts its tendency to combine with the potaſh, while the ſulphuric acid is at the ſame time attracted by the lime; ſo that the decompoſition of the ſulfate of potaſh is begun by the action of the nitric acid, and completed by that of the lime. To explain this double affinity ſtill more clearly, let us ſuppoſe the force of adheſion, which unites the ſulphuric acid with potaſh, to be equal to eight; the nitric acid tending to unite with that alkaline ſubſtance with a leſs degree of force, which we may eſtimate at ſeven, would be inſufficient of itſelf to decompoſe the ſulfate of potaſh; but the lime by its tendency to combine with the ſulphuric acid, aids it with a force which we may conſider as equal to ſix; and theſe two forces together amount to thirteen; which ſum of forces is exerted againſt the force eight, to ſeparate the ſulphuric acid from the potaſh. This compound force will alſo be greater than that which maintains the union between the lime and the nitric acid.

There are therefore two kinds of attraction in double elective attractions, which muſt be carefully diſtinguiſhed from each other: 1. The firſt is that by virtue of which the principles of each of the two compounds adhere to one another, which in the above inſtance retains the ſulphuric acid in union with the potaſh, and cauſes the nitric acid to adhere to the lime. I ſhall follow Mr Kirwan in giving to this force the name of *quieſcent attractions;* becauſe its tendency is to preſerve the two compounds in their firſt ſtate. 2. The ſecond is that by which the four principles of the two compounds reciprocally change their ſituations, and are combined in a different order: it is by virtue of this affinity, that in the above inſtance the potaſh combines with the nitric and the lime with the ſulphuric acid. This ſecond force I ſhall here denominate *divellent attractions*; becauſe it counteracts and deſtroys the firſt. From this uſeful diſtinction, it becomes eaſy to explain the cauſe of this double decompoſition, by exhibiting in a table, as Bergman has done, the forces of the attractions by which it is produced. Place the two compounds which mutually decompoſe one another between two braces directly oppoſite, the acids ſtanding in oppoſition to the baſes on which they act; between theſe four bodies note down the particular degrees of the attractive force which they exert upon each; add together the two horizontal num-

bers

bers, expreſſing the quieſcent attractions; add alſo the vertical numbers which are employed to mark the divellent attractions: if the ſum of the latter exceed that of the former, a double decompoſition and a double combination will be effected. The uſefulneſs and accuracy of ſuch a table may be ſhown at once by giving an example of it in the laſt mentioned compounds.

EXAMPLE.


Nitre, or nitrate of potaſh.
Potaſh
7
Nitric Acid.
divell. attrac.
Sulfate of Potaſh.
8 quieſcent attract. 4 = 12
Calcareous Nitrate.
6
Sulphuric Acid.
=
13
Lime.
Sulfate of lime *.

Chemiſts have but lately begun to take notice of theſe double elective attractions; and we are far from knowing them all. Thoſe who are engaged in chemical reſearches will frequently obſerve this kind of decompoſition in circumſtances where no ſuch phenomenon was before ſuſpected to take place. In the hiſtory of ſaline ſubſtances we will repeatedly have occaſion to take notice of ſeveral of thoſe double elective attractions which

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* I have given ten ſimilar examples of double decompoſitions which take place in the mixture of neutral ſalts, in two diſſertations; which the reader may conſult. *See my Memoirs and Obſervations on Chemiſtry*, Vol. I. 8vo, Paris, 1784, pages 308 and 438. F.

which have been lately obſerved by Bergman, Scheele, &c. and by ourſelves.

Before concluding our account of this tenth and laſt law of the attraction of compoſition, we cannot help taking notice of an ingenious method contrived by a French chemiſt, to exhibit at once all the more regular phenomena of chemical decompoſition. Geoffroy the elder, obſerving the various relations which ſubſiſt between different bodies, and the precipitations produced in conſequence of thoſe relations, with more attention than had been applied to that object by former chemiſt, contrived, in the year 1718, to exhibit them in a table; in which he arranged thoſe bodies whoſe affinities he had obſerved, in the order of their affinities. We only mention that ingenious contrivance in this place; but will have many future occaſions in the courſe of this work, of explaining it more particularly. Geoffroy gave that table only as a firſt attempt, to which he well knew much might be added. A number of chemiſts have adopted and enlarged his plan. Rouelle the elder made ſome corrections on his table, and added ſeveral columns to it. M. de Limbourg, a phyſician at Spa, in an excellent diſſertation on the affinities, which, in conjunction with another by M. Sage of Geneva, gained the prize offered in 1758 by the academy at Rouen, has formed one ſtill more extenſive. M. Gellert, in his Metallurgic Chemiſtry, has likewiſe given a new table of affinities. But none has contributed more to the advancement of this part of the ſcience than Bergman, profeſſor of chemiſtry at Upſal; whoſe labours have been ſo beneficial to the ſcience in general. That celebrated chemiſt has followed M. Baumé, in diſtinguiſhing the attractions which operate in the humid way, from thoſe which effect combinations in the dry way. He has given two very extenſive tables, in which he exhibits the elective attractions of a vaſt number of natural bodies. To the ſame philoſopher we are indebted for a very ingenious table, in which he has found means, by a peculiar diſpoſition of the chemical characters, to expreſs the phenomena of double elective attraction: Of this we gave an example above,

After giving this view of the leading phenomena of chemical attraction, and unfolding the laws by which that force appears to be regulated, we muſt obſerve, that in ſome caſes theſe laws ſeem liable to certain variations. We need not here mention all the facts on which this aſſertion is founded, as we ſhall be careful to take notice of them wherever they occur; only we may obſerve, that theſe ſeeming anomalies of chemical attraction ariſe from the influence of particular circumſtances; ſuch as the quantity of the ſubſtances, the temperature of the atmoſphere, motion or reſt, ſolution by water or fire, that is, in the humid or in the moiſt way, the ſtate of aggregation proper to each body, &c. Bergman has conſidered all theſe circumſtances with peculiar care; and has ſhewn how far they may be expected to vary the laws of attraction. From the various facts which he has collected relative to this ſubject, he concludes, that their variations can be regarded only as exceptions, by no means ſufficient to weaken the evidence on which the doctrine of chemical attraction is founded.

We are led to conſider two other ſpecies of affinity that have been admitted by ſome authors, in the ſame light, the affinity of *intermediates* and the *reciprocal* affinity. By the firſt, they underſtand that by which bodies, which have no natural tendency to mutual union, are capable of being united after one of them has been combined with a third body, which ſerves as an intermediate between them: Oil, for inſtance, does not combine with water; but a combination of oil with a ſalt conſtitutes a ſoap, which is ſoluble in water, the ſalt acting as an intermediate. But it is not the ſalt which renders the ſoap ſoluble, for its properties are entirely loſt in the ſoap; the ſolubility of this compound in water is owing to the new properties it has acquired. This phenomenon falls evidently under the ſixth law of chemical attraction; by which it is eſtabliſhed, that compounds acquire new properties totally different from thoſe of their component principles.

The *reciprocal affinity* takes place when a compound conſiſting of two bodies is decompoſed by a third, and the ſeparated principle again decompoſes the new combination; ſo that the principles ſeem to act reciprocally. The ſulphuric acid has a greater affinity than the nitric acid with potaſh, and accordingly decompoſes a combination of theſe two principles; but the nitric acid, when left in a ſeparate ſtate, has power to divide the ſulphuric acid from the alkali; for by heating ſulfate of potaſh with the nitric acid, nitre is again obtained. This kind of affinity, admitted by M. Baumé, is occaſioned by two circumſtances, whoſe influence diſturbs the general laws of chemical affinity. The common nitric acid muſt be heated before it can decompoſe ſulfate of potaſh; and the nitre obtained by this proceſs is again decompoſed by the ſulphuric acid, aſſoon as the mixture returns to a cold ſtate. The fuming, or *nitrous acid*, decompoſes ſulfate of potaſh cold; fuming ſpirit of ſalt or muriatic acid effects the ſame decompoſition, according to M. Cornette: but Bergman has very properly obſerved, that the odorating and fuming acids, which he calls *phlogiſticated*, have affinities different from thoſe which belong to them in their ſimple ſtate. Beſides, in theſe caſes but a very trifling part of the ſalt is decompoſed.

In all theſe inſtances, the order of the elective attractions is changed and modified by particular circumſtances. The reſt of the facts on which Mr Baumé eſtabliſhes the exiſtence of the reciprocal affinity, ſuch as the decompoſition of ammoniacal muriate by chalk, and of calcareous muriate by *concrete volatile alkali*, come properly under the double affinities; as ſhall be ſhown when we treat of thoſe ſalts.

All that now remains to be ſaid on chemical attraction is, to give ſome account of the different opinions which have been advanced by philoſophers concerning the cauſe of this force *.

The firſt who attempted to form a theory on this ſubject, thought that it muſt ariſe either from the elementary particles of bodies being all of the ſame form, or from the phyſical configuration of the parts, or laſtly, from ſome occult relations of their intimate compoſition. Theſe notions proceeded naturally from the mechanical explanations which were applied to all the phenomena of nature, in the infancy of the ſcience of natural philoſophy.

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* That beautiful general fact, *that all particles of matter, which are ſuſceptible of union by chemical affinity, continually tend to form bodies of a polyhædral, conſtant, and determinate form*; appears to have been ſufficiently aſcertained by *Linnæus*, M. Romé de Lille, and the Abbé Hany; to deſerve a place among the laws of chemical attraction—H.

Moſt of the modern chemiſts who have attempted to explain the cauſe of chemical attraction, have obſerved a remarkable analogy between this force and the general attraction diſcovered by Newton. Conſidering nature as ſimple and uniform, they have been led to conclude, that the power poſſeſſed by bodies of entering into mutual union, muſt depend on the ſame general laws as that by which all bodies are attracted towards each other. They have compared the minute bodies on which the force of affinity acts, with thoſe enormous maſſes which compoſe the ſyſtem of the univerſe; and have ventured to affirm that it is the force of gravitation which cauſes the former to approach each other, and enter into combination. Several perſons, adopting this opinion, but modifying it in a particular manner, have concluded, that chemical attraction was in the ratio of the gravity of bodies, and that thoſe bodies which were of the greateſt ſpecific gravity poſſeſſed always the ſtrongeſt affinities. This hypotheſis is ſometimes indeed juſtified by facts, and agrees with the affinities of many of the acids; but is contradicted by the phenomena of a vaſt number of decompoſitions, particularly of all thoſe in which metallic ſubſtances are concerned. Some chemiſts have been even ſo ſtrongly perſuaded of the exiſtence of an analogy between the attraction of large bodies and chemical attraction, as to imagine it poſſible to meaſure and calculate the former in conſequence of our knowledge of the latter. M. de Morveau, whoſe opinions are likely to have conſiderable weight with other chemiſts, has made a number of experiments with a view to prove the truth of the above aſſertion. Applying to a ſurface of mercury plates of metal of the ſame diameter, ſuſpended from the arm of a balance, the other arm of which carried a diſh, he next put weights into the diſh ſufficient to raiſe the plate of metal over the mercury; and he actually found, by making comparative trials of different metals, that theſe adhered to the mercury with different degrees of force, proportioned to the affinities known to ſubſiſt between them and that ſubſtance. Gold adhered with the greateſt force to the mercury, a greater weight being neceſſary to raiſe it than to raiſe any of the other metals: Cobalt, again, which is known to have no affinity with mercury, ſeemed to have no adheſion with that ſurface, and was elevated above it with the greateſt eaſe. But we muſt uſe the freedom to obſerve, that from ſeveral circumſtances, ſuch experiments cannot but be in ſome degree fallacious: the inferior ſurface of the ſmooth plates of metal applied to the mercury, cannot but combine with that ſubſtance; and the amalgam formed by this event being more or leſs, according to the eaſe or difficulty with which the metal unites with the mercury, this combination increaſes the weight of the plate, and renders a greater force requiſite to raiſe it above the mercury. A plate of metal adhering to a ſurface of mercury, cannot be raiſed above it without dividing the mercury into two layers; ſo that the force neceſſary to raiſe this plate is employed rather in overcoming the mutual adherence of the particles of the mercury, than in dividing the mercury from the metal.

It muſt be acknowledged then, that if chemical attraction be the ſame with general attraction; yet the difference of the laws by which theſe two forces are regulated, proves the former to be a particular modification of the latter. This truth becomes evident from a compariſon of thoſe laws of the Newtonian attraction with which we are acquainted, with the general facts relative to chemical attraction which have of late been diſcovered: The former acts only upon large bodies, and in the direct ratio of their maſſes; the latter affects only minute bodies, and has abſolutely no influence on ſuch as are of any conſiderable bulk. Attraction acts between bodies placed at an immenſe diſtance from each other: affinity never acts but between bodies in mutual contact. In deſcribing the laws of chemical attraction, we have laid before our readers the facts on one ſide of this compariſon: and we are induced to conclude, that the phenomena which theſe two great laws preſent, are ſtill ſo ſtrikingly different, as to render it highly proper for philoſophers to diſtinguiſh between them *.

CHAP.

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* I cannot help obſerving here, that the only true and preciſe definition of chemiſtry; and which, ſo far as I know, has hitherto been given by no writer or lecturer on that ſubject; is the following; CHEMISTRY IS THAT SCIENCE WHICH INVESTIGATES THE MODIFICATIONS OF THAT ATTRACTION WHICH TAKES PLACE ONLY BETWEEN THE MINUTE, COMPONENT PARTICLES OF BODIES.—H.

CHAP. IV.

Concerning the Principles of Bodies.

IT has been the opinion of philoſophers in all ages, that notwithſtanding the vaſt diverſity of the bodies of nature, they are all compoſed of a few primary ſimple ſubſtances; and to theſe they have given the name of *Principles.* The analyſes of chemiſtry, which afford the ſtrongeſt facts in proof of this doctrine, having enabled chemiſts to form pretty accurate notions concerning the nature and differences of thoſe principles; they have admitted ſeveral kinds of them. But it muſt be remarked, that they have taken the word *principles* in an acceptation different from that in which it was uſed by the philoſophers of antiquity. Ariſtotle and Plato applied the name *principles* to a claſs of ſubſtances, which being of ſuch ſubtlety as to eſcape the obſervation of the ſenſes, conſtituted, as they thought, by their union, thoſe bodies of a leſs ſimple nature, and perceptible to the ſenſes, which ſtill continue to be known by the name of *elements.* Theſe are the ſame ſubſtances which have been by others philoſophers denominated *atoms*, or *monads.* But chemiſts, not preſuming to extend their ſpeculations to ſuch ſublime and ſubtle objects, comprehend under the general name of *principles*, all thoſe ſubſtances, whether ſimple or compound, which they obtain by the analyſis of bodies. But as the principles of bodies, when conſidered under this point of view, muſt be extremely various, they have divided them into *proximate* and *remote*. The firſt are obtained by a firſt analyſis, and are capable of being reſolved into other principles; thus, by decompoſing a vegetable ſubſtance, we obtain oils, mucilages, ſalts, and coloured particles; all which are proximate principles of the vegetable ſubſtance, and each of them may by a new proceſs be decompoſed into other principles. By remote principles, they underſtand thoſe ſubſtances which, being ſimpler than the proximate, enter into their compoſition. Thus, mucilage, one of the proximate principles of vegetables, affords by a new proceſs, oil, water, earth, &c. and theſe are the remote principles of the vegetable. Theſe two kinds of principles have been alſo diſtinguiſhed by other names; ſuch as *principiated*, applied to the proximate principles; and *principiant*, to the remote. Theſe epithets diſtinguiſh the former as ariſing from the combination of other ſimple principles; and the latter, as ſerving by their union to conſtitute bodies, which though of a leſs ſimple nature, may yet become the principles of new compounds. Some chemiſts, to render theſe diſtinctions more juſt and accurate, admit more than two kinds of principles: They call thoſe principles which appear ſo ſimple as to be incapable of farther decompoſition, *primary*, or principles of the firſt order: *ſecondary* principles are formed by the combination of the *primary*; the combination of the *ſecondary* conſtitutes *ternary* principles; and theſe united in a new compoſition, afford *quaternary* principles, &c.

Philoſophers have not uniformly agreed with regard to the number of the elements. The followers of Thales the Mileſian, who for his ſuperior knowledge was ranked among the ſeven wiſe men of Greece, and, according to Cicero, was the firſt among the Greeks who cultivated the ſcience of phyſics, conſidered water as the great principle of all material bodies. Anaximenes, aſcribing this character to air, ranked it, on that account, among the number of the gods. Others conferred this important function on fire; while ſome, among whom was Anaximander, the ſcholar of Thales, and maſter of Anaximenes, believed earth to be the principle of all things. Each of them ſupported his opinion by reaſonings more or leſs plauſible: But as the experimental ſciences of natural philoſophy and chemiſtry were then unknown, we can regard thoſe notions in no other light than as bold conjectures, which unfortunately happen to be totally deſtitute of foundation. About three centuries after theſe philoſophers, Empedocles, a phyſician of Agrigentum, imagined that the four ſubſtances, each of which had been in its turn held to be the principle of all things, were of equal ſimplicity; and therefore combined thoſe various opinions into one ſyſtem, admitting four elements, fire, water, earth, and air. His opinion was adopted by Ariſtotle and Zeno in the following century. What induced theſe philoſophers to conſider fire, water, earth, and air, as elements, ſeems to have been rather the bulk, quantity, and apparently uniform properties of theſe ſubſtances, than any accurate notions concerning their eſſential compoſition. Fire ſeems diffuſed through all nature, and its effects are always the ſame: Our globe is ſurrounded with a maſs of air, of which the quantity and eſſential properties ſeem to remain unvaried: An enormous maſs of water, whoſe depths are often unfathomable, covers more than half the globe: Laſtly, this globe itſelf, the bulk of which is more than equal to that of all the beings who inhabit it, taken together, ſeems to be formed of a ſolid matter little ſubject to change, and of ſuch a nature as renders it a proper baſe to fix the other elements. It ſeems to have been on account of the bulk and unvarying properties of theſe bodies, that the firſt philoſophers were induced to conſider them as the primary materials of which all natural bodies were compoſed.

The peripatetic doctrine of the ſchools ſupported the Ariſtotelian diſtinction of the elements till the ſixteenth century. The ſect of chemiſts who then began to prevail, introduced a new diſtinction of the elements. Paracelſus, who was rather an artiſt than a philoſopher, haſtily inferred from the reſults of his operations, that there were five principles: namely, ſpirit, or mercury; phlegm, or water; ſalt; ſulphur, or oil; and earth. By ſpirit, or mercury, he underſtood all volatile odorate bodies; but theſe properties are far from being peculiar to ſimple bodies. Water, or phlegm, comprehended all aqueous, inſipid, products; but theſe properties are no ſurer indications of ſimplicity than the former. The word ſulphur, or oil, he applied to all inflammable liquid ſubſtances, and of conſequence to a great number of compounds, ſuch as the unctuous and eſſential oils, &c. By ſalt, he meant all bodies poſſeſſing the three properties of dryneſs, taſte, and ſolubility; which properties likewiſe belong to many compounds. Laſtly, Paracelſus applied the word earth to all thoſe fixed, dry, and inſipid, reſidues which are obtained in moſt operations, and are now known to be very different in their natures.

Beccher, who has treated of the ſcience of chemiſtry in a very philoſophical manner, being aware of the objections to which this ſyſtem of Paracelſus was liable, and convinced of its inaccuracy, attempted to diſtinguiſh the elementary principles of bodies in a different manner. He firſt aſſumed two principles very different from one another; moiſture and dryneſs, earth and water. The latter of theſe he divided into three ſpecies; namely, vitrifiable, inflammable, and mercurial earth. His vitrifiable earth was that which, taken alone, was not ſuſceptible of any alteration, but poſſeſſed the property of forming a glaſs when mixed with a certain ſaline ſubſtance: he likewiſe aſcribed to it the quality of rendering thoſe bodies into the compoſition of which it entered, ſolid, and almoſt incapable of alteration. Inflammable earth was that which rendered all the bodies into which it entered capable of combuſtion: Beccher conſidered it as being likewiſe the cauſe of odour, colour, and volatility. Mercurial earth he conſidered as exiſting in mercury, arſenic, the muriatic acid, &c.; and the diſtinguiſhing characteriſtic which he aſſigned it, was to communicate an high degree of both gravity and volatility to thoſe bodies of which it conſtituted part, though theſe two qualities ſeem directly oppoſite and inconſiſtent. Stahl adopted and illuſtrated the doctrine of Beccher. He conſidered inflammable earth as fire exiſting in a fixed ſtate, and gave it the name of *phlogiſton.* He found himſelf unable to demonſtrate the exiſtence of mercurial earth; and we have hitherto obtained no certain knowledge concerning that principle. Stahl paid great attention to combinations of earth and water, and ſtill more to phlogiſton, but has ſaid ſcarce any thing of thoſe which contain air; which Hales, nearly about the ſame time, diſcovered to act an important part in chemical phenomena.

From the days of Beccher and Stahl to the preſent time, chemiſts have made no change on the doctrine of the elements eſtabliſhed by the philoſophers of antiquity. They have followed Empedocles in acknowledging four principles, each of which they have conſidered as exiſting in two different ſtates. 1. As free and inſulated; and in this ſtate have the atmoſphere, large maſſes of water, fire in general, and the globe viewed as one whole, been conſidered: 2. As combined; and then the air, water, and earth obtained by the *laſt* analytical operations that can be performed on bodies, are the ſubjects of inquiry.

Such nearly were the opinions concerning the principles and elements of things that prevailed from the time of Beccher and Stahl, till the noble diſcoveries of Prieſtley and Lavoiſier, concerning fire, air, and combuſtion, exploded theſe, to make way for others better founded. In fact, if immutability of properties, unity and ſimplicity, be the genuine characteriſtics of elements, and if this ſimplicity of character belong only to ſuch bodies as we cannot reduce by decompoſition, it is to be remarked, *1ſt*, That of the four elements there are two, air and water, which art has at length found means to decompoſe and ſeparate into ſeveral principles. *2dly*, That elementary earth is merely the creature of fancy; as there are a variety of earthy ſubſtances all equally ſimple and imcapable of decompoſition, as ſhall be ſhown in the laſt chapter of this firſt part: *3dly*, That there are many natural bodies, ſuch as ſulphur and the metals, which no art has yet been able to decompoſe, and which muſt therefore, in the preſent ſtate of our knowledge, be conſidered as ſimple ſubſtances.

From theſe general conſiderations, ariſing from facts which ſhall be more particularly related in the following chapters, and through the ſeries of the work, it appears, that the true principles, or primary elements of natural bodies, eſcape the obſervation both of our ſenſes and of thoſe inſtruments which we employ to aid the imperfection of our ſenſes: that many of thoſe ſubſtances which have been called elements on account of their bulk, their influence on the phenomena of nature, and their being found to exiſt in many of its productions, are far from being ſimple and unchangeable: and that, in truth, none of the bodies with which we are acquainted, is a ſimple ſubſtance, though we may aſcribe this character to ſuch as we have not hitherto been able to decompoſe. And theſe aſſertions entirely agree with the opinions of ſome antient philoſophers, who conſidered not the elements as the ſimpleſt of ſubſtances, but believed them to be formed of principles infinitely more ſubtle and immutable.

What we advance concerning thoſe ſubſtances which have for ſo many ages enjoyed the excluſive title of elements, but are now diveſted of that prerogative, does not hinder us from conſidering fire, water, earth, and air, as forming the component principles of moſt natural bodies.

Let us diſmiſs this ſubject with an account of the terms which have been employed by ſome perſons to diſtinguiſh bodies, according as their compoſition is more or leſs complex.

The combination of two elements forms a body that is called a *mixed;* the union of ſeveral mixeds conſtitutes a *compound;* two compounds make a *ſurcompound;* the combination of ſurcompounds gives a *decompound;* two or more of theſe united make a *ſurdecompound.* It would be difficult to give inſtances of theſe ſeveral kinds of compoſitions; we could indeed go no farther than to the ſurcompound. Theſe diſtinctions are, therefore, merely fanciful, and can be of no real uſe in ſcience. Macquer, to whom chemiſtry is much indebted for the preſent perſpicuity of its doctrines, propoſes to explode this barbarous and inaccurate nomenclature, and to adopt in its room, Firſt, Second, Third, and Fourth Order. We might even purſue the ſame thought, ſo far as to adopt theſe names to diſtinguiſh principles according to the order of the analyſis by which we obtain them.

CHAP. V.

Of Fire.

THOUGH we cannot agree to receive the word *element* in the ſame ſenſe in which it was generally underſtood till the preſent time; though we cannot conſider thoſe four bodies, commonly called *the four elements*, as the firſt principles of all others, and the ſimpleſt productions of nature; yet we are willing to inquire into their nature before proceeding to others; becauſe a knowledge of their properties is neceſſary to enable the reader to underſtand our account of the properties of other ſubſtances, and becauſe they cannot be arranged under any of the diviſions of natural hiſtory, being confined to no particular departments in nature, but extending equally through all.

None of the four elements diſplays greater activity or ſimplicity than *Fire*. The more ancient philoſophers, who in this particular have been uniformly followed by their ſucceſſors, gave this name to a ſubſtance which they ſuppoſed to be fluid, active, penetrating, conſiſting of particles actuated by a lively and inceſſant motion, and the firſt principle of all fluidity and motion. Whoever conſiders this ſubject, muſt readily perceive, that it was merely by conjecture they aſcribed theſe properties to a particular elementary body: for though the exiſtence of the other three elements have always been undeniably eſtabliſhed, yet the exiſtence of this has never been demonſtrated. There is reaſon to think, that in all languages, and among all nations, the firſt uſe of this word was to denote the impreſſion which hot bodies make upon the ſkin; and that it is ſignificant of the light which iſſues from bodies in combuſtion, as well as ſynonymous with the word *heat*. Many have conſidered it in this view, admitting the exiſtence of fire only where heat is felt or combuſtion carried on. Chancellor Bacon was among the firſt that began to doubt the exiſtence of fire as a particular fluid; and obſerved, that natural philoſophers, in defining it, had always miſtaken a property for a ſubſtance. Boerhaave, whoſe Treatiſe on Fire will be ever regarded as a maſterpiece, was ſenſible of this difficulty; and in order to diſcover the properties of this pretended element, examined what effects it produces on thoſe bodies in which it is believed to exiſt; ſo, like former philoſophers, he has rather given the hiſtory of hot, luminous, rarefied, and burning bodies, than of fire. This difficulty muſt ever continue to perplex the philoſopher. The properties of fire cannot but be intimately connected with thoſe of the bodies on which it acts; we can form no idea of it as exiſting in a ſeparate ſtate. Notwithſtanding the preſent advanced ſtate of chemiſtry, the exiſtence of this ſubſtance is ſtill undetermined. Philoſophers continue to believe in its exiſtence, but are able to give a ſatisfactory explanation only of its effects. Theſe difficulties have induced ſeveral chemiſts, among whom was the celebrated Macquer, to conſider fire as being nothing more than light, and heat as a certain modification of bodies, produced by the motion and colliſion of their component particles. But this opinion no longer prevails among thoſe who cultivate chemiſtry. In order to enter into the ſeveral theories which have of late been advanced concerning fire, we muſt conſider it in a more particular manner. To acquire an accurate knowledge of this matter, and to comprehend that immenſe ſeries of facts which at preſent conſtitute the body of the ſcience of chemiſtry; we muſt make a methodical diviſion of our ſubject, examine and diſcuſs with pains its ſeveral parts and ſubdiviſions, and conſider in ſucceſſive order, as ſo many diſtinct effects of fire,—light, heat, rarefaction, the changes produced on bodies by heat, and the particular qualities aſcribed to fire in a ſtate of combination, when it obtains the name of Phlogiſton, &c.

§ I. *Of Light.*

The exiſtence of light is not doubtful, like that of fire: both its exiſtence and its properties are at preſent well known. This body, which is thought to iſſue from the ſun and the fixed ſtars, is the principle which enables the organs of ſight to inform us of the preſence of other bodies. Without it we ſhould be involved in perpetual darkneſs, and our eyes would be entirely uſeleſs. Being reflected in right lines from the ſurfaces of thoſe bodies on which it falls, it ſtrikes the eyes in ſuch a manner as to paint on the retina the images of thoſe objects from which it is reflected. Means have been found to collect its rays in a darkened chamber, in ſuch a manner as to render their properties ſubject to examination, by exhibiting them diſtinct from the bodies which they illuminate.

The motion of light is ſo rapid, that it paſſes through the ſpace of eighty thouſand leagues * in a ſecond of time, according to the moſt eminent aſtronomers. It moves in a rectilinear direction, and conſiſts of rays, which, after iſſuing from the ſtars, ſeparate and diverge in obedience to the impulſe originally communicated to them. Such is their elaſticity, that when they fall on a ſurface capable of reflecting them, the angle of their reflection is nearly equal to that of their incidence; as is ſeen in the ſtudy of catoptrics. When light paſſes near any body, it is more or leſs inflected towards that body; which inflection, by evincing its gravitation, ſhows it to be a diſtinct ſubſtance.

However great its ſubtlety and velocity, yet it does not move invariably in a right line. Such bodies as meet and obſtruct its paſſage, cauſe it to deviate from its original direction. When paſſing obliquely out of a rare into a denſe medium, it is refracted like any other ſolid body; but Newton † diſcovered its refrangibility to be directly contrary to that of other bodies. Other bodies recede from the perpendicular line whenever they paſs into a denſer medium; but light, on ſuch an occaſion, approaches nearer to the perpendicular. To explain the laws of the refraction of light is the province of dioptrics.

When light reaches the ſurface of the earth, it diſcovers to animals the preſence of material bodies, and enables them to diſtinguiſh them into opaque, tranſpa-

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* Twenty-five of which make a degree; equal to 167,000 geog. miles. —H.

† We owe the firſt accurate account of theſe phenomena to Des Cartes.—H.

rent, and coloured. Its preſence is ſo neceſſary to render theſe properties perceptible, that in darkneſs bodies become totally undiſtinguiſhable. Difference of opacity, tranſparency, and colour in bodies, depends, therefore, on the manner in which they are affected by light, or in which they affect this ſubſtance. A body is tranſparent when the rays of light paſs eaſily through it; which depends no doubt on the form of its pores. As many tranſparent ſubſtances have great hardneſs and ſpecific gravity, the particles of light which penetrate through them muſt therefore be extremely ſubtle. As the particles of light paſs through thoſe ſubſtances, they are refracted in the ratio of their denſity, if they be ſtones, ſalts, or vitreous ſubſtances: but tranſparent bodies of the combuſtible claſs reflect the particles of light in a different ratio. Thus, yellow amber has a much greater refringent power than a ſaline cryſtal of equal denſity.

By examining the various refractions and reflections of light, the great Newton was at length enabled to decompoſe, or rather to diſſect, this body, ſo far as to diſcover that the rays which compoſe a beam of light were each of a peculiar colour. Before him men's notions of the cauſe of colours were very obſcure and indiſtinct. The refraction and reflection of each ray of light are determined by particular laws; and therefore when a ſtream of light is directed ſo as to fall on the angle of a triangular glaſs priſm, and the priſm is turned round on its axis; the rays which compoſe the ſtream of light being refracted according to different laws, are ſeparated in paſſing through the glaſs, and if received on a plane white ſurface, form a long ſpectrum, conſiſting of the ſeven following colours; red, orange, yellow, green, blue, purple, and violet.

The ſurfaces of opaque variegated bodies produce the ſame effects as the priſm on light. Such ſeems to be the cauſe of that diverſity of colours which conſtitutes ſo conſiderable a part of the beauties of nature: When all the rays which fall upon any opaque body are reflected, without ſuffering any abſorption or ſeparation by that ſurface, they ſtrike our eyes with all their luſtre, and the colour produced is a white: But again, if the ſame rays fall on a ſurface by which they are all abſorded, the eye then beholds a deep ſhade; which being a direct contraſt to the former, conſtitutes black, or rather abſolute negation of colour. In ſhort, as every beam of light conſiſts of ſeven different coloured rays, of various degrees of refrangibility, what diverſifies the colours of natural bodies is the various diſpoſition of the particles of their ſurfaces; ſome of which reflect one ray, abſorbing all the reſt, others another, and ſo on. Colour depends, therefore, on the nature of the ſurfaces of bodies, and tranſparency on the form of their pores; and both are occaſioned by the modifications produced on light, either by the ſuperficies or the interior parts of the bodies on which it falls. A blue or red colour is produced by the decompoſition of a beam of light, and the abſorption of all its rays, excepting the blue or the red.

Theſe are the chief properties of light, when conſidered in a free ſtate, or as it iſſues from the ſun and the fixed ſtars. But are we to examine it only in this free and inſulated ſtate? Is not this body, as well as all the reſt with which we are acquainted, ſubject to the laws of chemical attraction? The phenomena of light are not confined to the modifications which it ſuffers from the ſurfaces of bodies. Subſtances expoſed to its influence, by being immerſed in its ſtreams, often ſuffer an alteration and entire change of nature, without any other known cauſe; and it is reaſonable to think, that ſuch changes are produced by the operation of light, which is enabled to effect them by being capable of chemical attraction. Art, indeed, has not yet been able to determine whether theſe alterations be occaſioned by the decompoſition of light, or by that of the bodies in contact with it, or by the mutual decompoſition of both; which laſt is highly probable: but they are too numerous and too ſtriking to be paſſed over unnoticed. We ſhall here mention only a few of the moſt remarkable; becauſe our attention will be more particularly turned towards this object in the hiſtory of natural bodies.

Naturaliſts have long obſerved the influence of light on vegetation. Thoſe engaged in the cultivation of plants firſt obſerved, that ſuch as grow in the ſhade are of a paler colour. This phenomenon has received the name of *ætiolation*; and the plants on which it takes place are ſaid to be *ætiolated*. Herbs growing under ſtones are white, ſoft, aqueous, and inſipid. Gardeners take advantage of this circumſtance to ſupply our tables with white and tender herbs and pulſe; for they bind their leaves ſo cloſely together, that the exterior defend the interior from the contact of the light. The colour of herbs is pale or deep in proportion as they are leſs or more expoſed to the rays of the ſun; and in conſequence of this, the nations of the eaſt obtain from the wood, bark, or roots of trees, many of the moſt valuable colouring ſtuffs, both for permanency and luſtre, which all the ingenuity of European dyers has never been able to imitate.

Colour is not the only property that vegetables derive from the influence of light. From the ſame ſource they acquire taſte, ſmell, and combuſtibility. Thus light contributes to the ripening of fruits and ſeeds; and under the torrid climate of America, vegetables in general are highly odorous, ſapid, and reſinous, &c. Laſtly, light exerts ſo powerful an energy on the organization of vegetables, that when the rays of the ſun fall upon them, their leaves pour from their ſuperior pores copious ſtreams of vital air; but when hid from the influence of that planet, they exhale a deleterious mephitic, or rather a real acid, of the ſame nature with that which is extracted from chalk. This important diſcovery was firſt made by Dr. Prieſtley. M. Ingenhouſze has proſecuted it much farther; and from the experiments and obſervations of both, it appears how powerful the influence of light is on vegetation. In a great number of chemical operations, light is found to act with the ſame energy as in theſe more general inſtances. There is not one ſubſtance in nature, that, if put into a cloſe glaſs veſſel, and expoſed to the rays of the ſun, will not ſuffer ſome alteration from their influence. Theſe alterations are moſt remarkable in mineral acids, oxides, or metallic calces, vegetable powder, and volatile animal oils. Not a ſingle metallic oxide, though more eſpecially that of mercury, but ſuffers a change of colour, aſſuming generally a deeper ſhade from being expoſed to the rays of the ſun. Painters' colours which are kept by merchants in glaſs bottles, afford a good inſtance of this. Mineral acids expoſed to the ſun become fuming, higher coloured, and more volatile; metallic ſalts become black; animal oils aſſume a brown duſky colour. All theſe changes merit the moſt careful attention of chemiſts; they afford vaſt ſcope to reſearch, and have not hitherto been obſerved with ſufficient care. Scheele was the firſt who deſcribed any of them. M. Berthollet has alſo turned his views to this object; and we ſhall afterwards ſee that he has determined accurately what paſſes in many of theſe alterations.

§ II. *Of Heat.*

To examine the properties of heat is a much more difficult taſk than to examine thoſe of light. Bodies when heated acquire no additional gravity; which might ſerve to prove that heat is a diſtinct ſubſtance. Bacon, and many other great men, have thought heat to be only a certain modification of which bodies are ſuſceptible. It is certain that natural philoſophers, as well as other men, have always conſidered its preſence as a ſure indication of the preſence of fire; have ſometimes confounded it with that element; and ſometimes conſidered heat as one of the diſtinguiſhing properties of fire.

Its leading properties are, to penetrate through all bodies; to diffuſe itſelf equally, and to tend to an equilibrium; to dilate all ſubſtances into which it inſinuates itſelf, cauſing them to paſs from a ſolid to a fluid ſtate, and from this to aſſume the form of elaſtic fluids.

Heat is uſually communicated to bodies in one or another of theſe three ways; by contact, by motion, or by combination. Every perſon muſt have obſerved, that when two fluids different in temperature, the one ſenſibly warm, and the other ſenſibly cold, are mingled together, the former loſes part of its heat, which is communicated to the ſecond, ſo that the temperatures of both become the ſame. It is equally well known, that when two ſolids, the one warm, the other cold, approach each other, the latter robs the former of part of its heat, and the temperatures become equal. As to the calling forth of heat by motion; the friction of any two ſolid ſubſtances, ſuch as two hard ſtones, two pieces of wood, ivory, or metal, produces a heat which often riſes to inflammation. The production of heat by combination is no leſs undeniable. The union of concentrated acids with water, quicklime, pure alkalis, or metals, is productive of a ſtrong heat: the combination of certain fluids, ſuch as oil and ſpirit of nitre, is even ſo powerful this way as to cauſe inflammation.

The laws of the communication of heat were conſidered as analogous to thoſe of motion, till the labours of Meſſrs Black of Edinburgh, Wilcke of Stockholm, Irvine of Glaſgow, Crawford and Kirwan of London, and Lavoiſier of Paris, gave us new and more accurate ideas on the ſubject. The reſearches of theſe philoſophers have ſhown, that nothing was leſs known, or involved in greater difficulties, than the progreſs and communication of heat among bodies unequally heated. Their experiments, though highly ingenious, are not yet ſufficiently numerous. They themſelves do not preſume to conſider their obſervations as of ſufficient weight to form an elementary part in the ſcience of chemiſtry: But it is highly probable that theſe will lead to the eſtabliſhment of a general theory, which may be applied to all the phenomena of chemiſtry; in every one of which heat acts a part, by either its abſorption or diſengagement.

Even the niceſt and moſt accurate obſervations have been hitherto inſufficient to afford us any determinate ideas of the nature of heat; and both chemiſts and natural philoſophers are ſtill divided in their opinions on this ſubject. Part follow Bacon of Verulam, in conſidering heat to be nothing more than a modification of which all natural bodies are ſuſceptible; which has no ſeparate exiſtence, but conſiſts in the oſcillation of the minute particles of bodies. This was Macquer's opinion. The philoſophers who maintain it, ſupport it on the following facts. Heat accompanies all the phenomena of motion, and appears ſubject to the ſame laws: It is increaſed with the increaſe of motion, and diminiſhed by its diminution. Excepting its communication or paſſage from one body into another, in which it follows laws different from thoſe of motion: in all other reſpects there is a ſtriking analogy between the two; and when this cauſe acts with leſs force, or entirely ceaſes to act, heat is inſtantly diminiſhed, and ſoon totally loſt. To explain this hypotheſis, the philoſophers by whom it is maintained obſerve, that even bodies of the greateſt denſity are full of ſmall cavities or pores, the ſum of which if they were taken together would perhaps occupy a larger ſpace than the ſolid matter of the body that contains them. Theſe void ſpaces afford room for the particles to move one againſt another in a continual oſcillation. The oſcillations are not obſerved, becauſe both the particles and pores are ſo ſubtle and minute as to elude our ſenſes. Laſtly, The philoſophers who regard heat as an internal motion, urge that no experiment has hitherto demonſtrated its exiſtence in a ſeparate ſtate, and that it makes no addition to the gravity of bodies, &c.

On the contrary, many other philoſophers, and ſome modern chemiſts, are of opinion, that heat is a particular fluid, diffuſed through all nature, of which every body contains more or leſs. They diſtinguiſh this fluid as exiſting in two different ſtates,—in combination, and at liberty. In the former ſtate, it neither affects our ſenſes nor the thermometer, but remains quieſcent in thoſe bodies of which it conſtitutes a principle; it is then more or leſs in a ſtate of confinement. In the decompoſition of the bodies it is often diſengaged, and eſcapes into a ſtate of liberty: it now becomes capable of acting on bodies expoſed to its influence; and its force is meaſurable by a graduated thermometer. As all bodies that paſs from a ſolid to a fluid ſtate, and thence into a vaporous form, excite cold in the ſurrounding atmoſphere, they ſuſpect that ſuch bodies abſorb a great quantity of heat; and when fluids, by aſſuming a concrete form, generate heat, they think that heat is then diſengaged from thoſe ſubſtances, and paſſes from a ſtate of combination into a ſtate of liberty.

Scheele, as well as Bergman, being perſuaded that heat is a diſtinct ſubſtance, has examined with great attention all the phenomena which it diſplays as a chemical agent ſuſceptible of combination. He has even thought himſelf warranted by his experiments to conclude, that it is a combination of vital air, which he calls *empyreal fire*, and fixed fire or phlogiſton, and differs from light only in the relative quantity of the laſt principle. But however ingenious and accurate his experiments, the inductions which he has drawn from them concerning the nature and principles of heat, do not appear to be naturally deducible from the facts; and we cannot conſider his analyſis of heat as fully demonſtrated to be juſt. Some philoſophers are of opinion, that light and heat are the ſame ſubſtance, only exiſting in different ſtates. This ſubſtance becomes light, when its particles being collected together, and poſſeſſing all their attractive force, are violently darted to a diſtance: it aſſumes the character of heat, when the ſame particles exiſt in a ſtate of diviſion, move gently, and tend towards an equilibrium. Heat may be converted into light, and light again into heat. It muſt be acknowledged, however, that light often produces effects very different from thoſe of heat; as on the nitric acid, the oxigenated muriatic acid, the calces or oxides of metals, and the leaves of vegetables dipped in water; all which bodies afford vital air or oxigenous gas when expoſed to the rays of the ſun, which can be obtained from ſcarce any of them by the operation of heat. Thus the artificial light of our fires paſſing through veſſels, changes the nature of the products which it diſengages. Laſtly, Meſſrs. Lavoiſier and De la Place ſeem to think both theſe opinions true: they conſider heat as a diſtinct ſubſtance, which by its preſence in natural bodies occaſions an oſcillation of their component particles.

But though the nature of heat be not certainly known, the phenomena to which it gives riſe in chemical combinations and decompoſitions are not the leſs certain on that account, and are worthy of careful obſervation. It appears from a vaſt variety of facts, that whether a body or a modification, it is of itſelf liable to no alteration, and is never loſt; and the conſideration of this has induced Meſſrs Lavoiſier and De la Place to form an axiom or general principle concerning its appearance or diſappearance. As that axiom is of the higheſt conſequence, we ſhall inſert it here.

"If in a combination, or in any change of ſtate whatſoever, there be a diminution of free heat, the whole of that heat will again appear when the ſubſtances are reſtored to their former ſtate; and on the contrary, if in any combination or change of ſtate there be an increaſe of free heat, this additional heat will diſappear when the ſubſtances return to their original ſtate."

They generalize this principle ſtill farther, ſo as to make it extend to all the phenomena of heat; and they then expreſs it in the following terms. "All the variations of heat, whether real or apparent, that any ſyſtem of bodies can ſuffer, are reproduced in an inverſe order when the ſyſtem returns to its original ſtate."

In order to meaſure the quantity of heat that is abſorbed or diſengaged in the various phenomena of chemiſtry, which appears from what has been ſaid, to be an object of the higheſt importance; modern philoſophers have endeavoured to find means for correcting the obſervations of the thermometer, and extending its ſcale. M. Wilcke propoſed to eſtimate the heats of bodies by obſerving what quantities of ſnow they could melt in a given time. Meſſrs Lavoiſier and De la Place have contrived a method which is more certain and more eaſily practicable; reducing ſubſtances that produce heat by their combination, as well as the veſſels in which they are contained, to the temperature of 32° Fahrenheit; they then put them into a veſſel laid round with ice; and as the interior ſurface of the ice cannot be melted but by the heat which is diſengaged while the ſubſtances are entering into combination, the quantity of the heat thus diſengaged may be meaſured by the quantity of the water obtained by the melting of the ice, which muſt be carefully collected*. By this proceſs they have been able to eſtimate the ſpecific heats of various bodies, to meaſure the quantity of heat abſorbed in various combinations, and even to determine how much is diſengaged in combination and reſpiration. We are obliged to refer our readers to the work of thoſe learned academicians themſelves, for an account of this ingenious inſtrument, and the manner in which it is to be applied to the varions purpoſes for which it is adapted; as the detail of particulars neceſſary to explain it would be inconſiſtent with that brevity which we mean to follow through the courſe of this work †.

Here let us conſider more particularly the reſemblance that appears in ſome inſtances between light and heat, as well as thoſe peculiarities by which they are diſtinguiſhed from each other in the operations both of nature and art. Though the light of the ſun's rays warm thoſe bodies on which it falls; yet we muſt not conclude from this circumſtance that light and heat are the ſame; there are a great many inſtances in which light is totally deſtitute of heat, and others again in which heat is not accompanied with light; and a number of philoſophers therefore conſider them as eſſentially different. In fact, phoſphori, diamonds, putrid wood, animal ſubſtances in a ſtate of putrefaction, luminous inſects and worms, as well as the rays of the moon, concentrated on metallic mirrors or lenſes, afford a ſtrong ſparkling light, but no ſenſible heat; and all the bodies in nature may be ſtrongly heated without becoming luminous.

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* We underſtand from the Philoſophical Tranſactions, that in ſome attempts made by an ingenious Engliſhman, it was found that even this method may be fallacious.—H.

† See a Memoir on Heat, read before the Royal Academy of Sciences on the 28th of June 1783, by Meſſrs Lavoiſier and De la Place of that Academy.—F.

The rays of the ſun appear to produce heat merely by their impulſe on the bodies on which they fall, or by the friction which they ſuffer from thoſe through which they paſs. Red, and more particularly black opaque bodies, are ſooner heated than white, bright ſurfaces; doubtleſs becauſe they refract the rays more powerfully, and perhaps even becauſe light enters into combination with thoſe high-coloured ſubſtances, while white ſurfaces do not abſorb, but reflect the rays which fall upon them.

With regard to the production of light by a ſtrong continued heat, as in the combuſtion of oils, wood, or greaſe, and the ignition of metals and ſtones; this may alſo be accounted for without allowing the indentity of light and heat. When combuſtible bodies are ſtrongly ignited, they at length produce flame; which has the ſame effects as the rays of the ſun, and ſupplies their abſence. But this light which is produced by inflammation, may have before ſubſiſted either in the combuſtible body or in the air, the preſence of which is neceſſary for its production: and this fact, therefore, affords no proof that heat may be changed into light. The ignition of incombuſtible bodies, ſuch as ſtones, in which light cannot ſubſiſt in a combined ſtate, not at leaſt in the ſame manner as in combuſtible bodies, has been very ingeniouſly explained by Macquer. In his opinion it depends on the ſtrength of the vibrations communicated to the particles of thoſe bodies by the impulſe of heat. Thoſe vibrations diſpoſe the particles in ſuch a manner, that their facets, acting like ſo many little mirrors, reflect upon our eyes the rays of light, which exiſt in the air by night as well as by day; for we are involved in darkneſs during the night, for no other reaſon but becauſe theſe are not then ſo directed as to fall upon our organs of ſight.

Such were the notions of Macquer and of many other philoſophers. But a very numerous ſeries of accurate facts concerning the differences of heat in bodies, the capacity of bodies to abſorb it, and the elective attractions to which it is ſubject, render the exiſtence of heat as a diſtinct body much more probable than ever. It is thought to be often a principle in compound bodies, and the lighteſt of all the ſubſtances in nature; and this laſt property is conſidered as the reaſon why we cannot determine its exiſtence by its weight. Heat is diſtinguiſhed into two kinds, or rather as exiſting in two different ſtates; in the one, it is intimately combined with other principles, and is denominated *latent heat*, or the *caloric* principle, becauſe it is not perceptible to the ſenſes; in the other, it is only diffuſed without combination. This laſt kind of heat may be expelled by preſſure: thus, when a bar of iron is ſtruck, the ſtroke compreſſes its particles and cauſes the heat to iſſue out, in the ſame manner as water iſſues from a wet ſponge when it is preſſed together with the hand. Combined heat cannot be ſeparated from the bodies of which it forms a part, but by means of new chemical combinations. All ſolid bodies that contain any portion of theſe two kinds of heat, are capable of receiving more of both. When you add a quantity of the ſecond ſpecies to any body, its firſt effect is to enlarge the pores that ſeparate its component particles, by which means it ſoftens a ſolid; next, as it gradually accumulates, it produces fuſion or liquefaction; and as the quantity of heat continues to increaſe, elaſtic fluidity follows: But we ſhall treat of theſe phenomena in the two following ſections.

§ III. *Of Rarefaction.*

RAREFACTION is the moſt remarkable of all the effects which philoſophers aſcribe to fire, and is conſtantly produced by heat. We have already taken notice that the chief effect of heat is to diminiſh the ſpecific gravity of bodies, by extending their bulk, without adding any thing to their abſolute weight. This rarefaction ſhows, that ſome new ſubſtance is introduced into the cavities of the rarefied body. This ſubſtance, which is no other than heat, acts in proportion to the interſtices which ſeparate the component particles of the body. Bodies when rarefied by heat gain no additional weight, and have their ſpecific gravity diminiſhed; becauſe rarefaction conſiſts ſimply in the ſeparation of the parts of the warm body, its pores being enlarged, ſo that there is more vacuity and leſs ſolid matter than before in a given ſpace. This ſeparation of parts is effected by heat, which is to us, in point of weight, a mere non-entity.

When we conſider, that the particles of bodies rarefied by heat, ſuffer an internal motion, which tends to divide them from one another; and that cold, on the contrary compreſſes and condenſes them; we are led to conſider heat as a force oppoſed to the mutual gravitation of thoſe particles, which weakens their particular attraction: For it is to be obſerved, that there are three modifications of the Newtonian attraction which ought to be carefully diſtinguiſhed from one another. The firſt ſtate of attraction is that which cooperates with a primary impulſe to retain the planets in their orbits, preventing them from approaching the ſun, upon whom they would ſoon fall were it not for the centrifugal force which they have received from primary impulſe; this may be called *planetary attraction*, to diſtinguiſh it from the other two. The ſecond ſtate or modification of attraction is that which cauſes bodies projected into the atmoſphere of our globe to tend towards the centere: this is *terreſtrial gravitation.* The third modification of this general force is that by which the ſeveral parts of any body tend to their common centre: ſuch as a ſtone or any other conſiſtent body: this force produces aggregation, and in its various degrees is the cauſe of ſpecific gravity: It is this laſt ſpecies that heat diminiſhes and tends to annihilate; and by acting in oppoſition to this force, it produces an infinite variety of effects in combination, decompoſition, vegetation, animalization, &c.

Boerhaave, who has examined the effects of fire rather as a philoſopher than a chemiſt, has eſtabliſhed three general laws concerning rarefaction, which we ſhall examine.

FIRST LAW.

All bodies are dilated by heat.

THOUGH it be a general truth, that heat dilates and rarefies almoſt all natural bodies, yet we may make a few remarks on this phenomenon. Firſt, all mineral ſubſtances without exception are dilated and rarefied in the direct proportion of the ſtrength of the heat to which they are expoſed. This rarefaction may even be carried ſo far as to deſtroy the aggregation of many among them; but vegetable and animal ſubſtances afford ſome exceptions to this law. A gentle heat indeed dilates their fibres, divides them, and thus diminiſhes their conſiſtency; but a ſudden ſtrong heat cauſes parchment, membranes, and tendons, to ſhrink and contract their bulk; which ſeems to be occaſioned by the irritability, or more properly the contractive force, of animal fibres, on which heat appears to act as a ſtimulus, till their organization be deſtroyed.

SECOND LAW.

All the dimenſions of bodies rarefied by heat, are dilated.

A BAR of iron ignited becomes both longer and thicker. Philoſophers have contrived ſeveral inſtruments for eſtimating, and even for meaſuring preciſely this effect of rarefaction. The pyrometer invented by Muſchenbroek, ſhows this by the dilatation of ignited bars of metal, ſo accurately as to diſtinguiſh the 1080th part of an inch. The communication of the expanſive motion through various levers, whoſe arms are of unequal lengths, occaſions this nice ſenſibility. The laſt of theſe moves through ſo large a ſpace, that it eaſily indicates, by means of a hand or index carried round by a wheel, the extremity of which points to a ſeries of numbers arranged round a circular plate of metal, the ſmalleſt degrees of dilatation that the bar ſuffers. As the pyrometer meaſures only the lengthening of bars of metal, philoſophers have made an experiment with a cylinder, which paſſes through a ring when both are cold; but when the cylinder is heated the ring cannot contain it; and it hence appears, that the diameter of bodies is dilated as well as their length.

On account of this fact, which is well known to chemiſts, it becomes neceſſary to leave room in the grates that are placed in furnaces, and not to crowd veſſels expoſed to heat too cloſely together: otherwiſe you are in danger of having them broken, and ſuffering various other inconveniences in your proceſſes.

THIRD LAW.

The dilatation of bodies is in the direct ratio of their rarity, or the inverſe ratio of their denſity.

BOERHAAVE laid down this law after comparing the effects of heat on no more but three ſolid bodies very different from one another, wood, ſtones, and metals. He had obſerved, that in proportion to their denſities wood was the moſt dilated by the ſame degree of heat, ſtones next, and after them metals. From this he ventured to conclude, that the more rare the conſiſtency of any body, the more eaſily is it dilated; and that the greater the denſity of a body, the leſs is it liable to rarefaction. But by examining the rarefaction produced by heat on a great number of bodies, M. Buffon has found that the dilatation of ſolid bodies by heat is in a direct proportion to their alterability by fire; ſtones are dilated in proportion as they are ſuſceptible of calcination, and metals in the ratio of their fuſibility. Boerhaave had likewiſe extended this law to fluids, without examining the dilatation of any fluid bodies but air, ſpirit of wine, and water. Had he compared the rarefaction of mercury with that of theſe bodies, he would ſcarce have ventured to lay down this general law. For mercury, though its denſity be greatly ſuperior to that of water or ſpirit of wine, admits of much eaſier dilatation than either of them. And from this fact it appears that the quickneſs or ſlowneſs of the rarefaction of fluids by heat depends on neither their inflammability nor fuſibility. Meſſrs Lavoiſier and Bucquet, who have made a long train of experiments on the dilatation and rarefaction of bodies by heat, have found themſelves unable to determine the cauſe of that amazing diverſity which appears among theſe phenomena, and have contended themſelves with deſcribing their experiments, without preſuming to deduce any induction from them.

Beſide theſe laws of the rarefaction produced by heat, which are ſtill but very imperfectly known, it is of importance to know. 1. That bodies always produce cold when they paſs from a ſolid to a fluid ſtate; as for inſtance, ſalts when diſſolved in water, evaporating æther, &c. 2. That fluids capable of aſſuming a concrete form, generate heat as they become ſolid: thus water, which freezes when put into a freezing mixture, never affords ſo high a degree of cold as ſpirit of wine put into the ſame mixture. It may be underſtood from what has been ſaid, that when a ſolid body becomes liquid, it abſorbs an additional quantity of heat; and when a liquid body becomes ſolid, part of the heat which it contained is diſengaged.

§ IV. *Of the Phlogiſton of Stahl.*

BECCHER, ſtruck with that property of certain bodies which enables them to produce fire, that is to ſay, light and heat, in conſequence of continued motion, or by coming into contact with other bodies in a ſtate of ignition, imagined it to depend on a diſtinct principle, to which he gave the name of *inflammable earth*. Stahl, whoſe attention was ſtrongly engaged by this doctrine, underſtood this principle to be pure fire, or the matter of fire fixed in combuſtible bodies. To this element, exiſting in ſuch a ſtate of combination, he gave the name of *phlogiſton*, or the *inflammable principle*, to diſtinguiſh it from fire in a free or active ſtate. Its properties, when combined, are totally different from thoſe which it diſplays when at liberty; it then gives neither heat nor light, though, in the latter ſtate, theſe are its conſtant attendants:

But, when freed from confinement, it conſtantly regains its characteriſtic properties, and its preſence is indicated by both heat and light. Such was the ſublime and ſimple idea of Stahl concerning the nature of combuſtible bodies. It is indeed natural to think, that thoſe ſubſtances which, when ſtrongly heated or forcibly ſtruck, become inflamed, and continue to burn till they be conſumed, owe this property to their latent fire; and that the combuſtion of ſuch bodies is nothing but the diſengagement of the fire, and its paſſing to a ſtate of liberty. According to Stahl, therefore, all combuſtible bodies contained fire in a fixed or combined ſtate, on which principle their inflammability depended. He alſo conſidered this principle as being perfectly the ſame in all the ſubſtances into which it entered, whatever their nature, or however different they might be from one another. The combuſtibility of any body appeared to him a ſufficient proof that it contained a quantity of phlogiſton. Thus, in his opinion, ſulphur, charcoal, metals, oils, and phoſphorus, owed all their properties to phlogiſton; and their differences in point of form, colour, conſiſtency, gravity, &c. might depend, he thought, on the variety of the principles to which the phlogiſton was united; for the phlogiſton itſelf was always the ſame, and could ſuffer no variation but by being diſmiſſed from a combined into a free ſtate.

In order to diſtinguiſh the properties of phlogiſton or fixed fire, Stahl inſtituted a compariſon between bodies into the compoſition of which it enters, and others that ſeem deſtitute of it. He obſerved the former to poſſeſs in general, colour, ſmell, fuſibility, volatility,

tility, and combuſtibility; while he found the latter to be commonly deſtitute of colour and ſmell, fixed in a greater or leſs degree, incapable of fuſion, and ſtill more incapable of combuſtion. He likewiſe obſerved, that ſuch bodies as evidently appeared to be phlogiſticated, loſt moſt of their properties when deprived of their phlogiſton, but regained them when it was reſtored.

He applied his doctrine chiefly to ſulphur and metallic ſubſtances: the phenomena which theſe afforded were the leading facts on which it was eſtabliſhed. Metals he conſidered as compounds of certain earths with phlogiſton. When calcined, their phlogiſton is diſengaged, and eſcapes into a ſtate of freedom; and they loſe, of conſequence, their fuſibility, ductility, and inflammability. You may cauſe them to recover theſe properties by heating them with oils, charcoal, or any other phlogiſticated ſubſtance, ſo as to reſtore to them what they before poſſeſſed of that principle. Sulphur is a combination of the ſulphuric acid and phlogiſton: its combuſtion conſiſts in the diſengagement of the latter principle; and when this is entirely diſengaged, nothing but the acid remains. By applying charcoal, oils, or metals to this acid, we can deprive them of a part of their phlogiſton; which being communicated to it, forms a new quantity of ſulphur, or a coloured, odorous, fuſible, volatile, and inflammable body.

However plauſible this theory may be eſteemed, yet, in conſidering it, one important difficulty occurs: Stahl and his followers have never told us preciſely what phlogiſton is, but have always expreſſed themſelves on this head in obſcure and indeterminate terms. Macquer, who was ſenſible of this difficulty, after having long conſidered the nature of fire and phlogiſton, concluded that light poſſeſſed all the properties aſcribed to it, either when in a ſtate of freedom and activity, or when united with other principles in compound bodies, and labouring to diſengage itſelf.

When we exhibit a view of a theory that has obtained a place in ſcience, it is but fair to point out what difficulties attend it, and to examine whether it be founded in error, or on the ſolid baſis of truth. We ſhall, therefore, mention the objections that are now made to the doctrine of that great chemiſt; a doctrine which has now loſt its luſtre, after having long made an illuſtrious figure in the ſcience.

The leading difficulties which occur in conſidering the theory of phlogiſton may be reduced to three heads: 1. The properties which Stahl attributes to that principle do not always appear in the bodies in which he ſuppoſes it to exiſt. Charcoal, and particularly that of reſinous bodies, which he conſiders as pure phlogiſton, is neither odorous, volatile, nor fuſible: there are even ſome ſpecies of charcoal which are ſcarce combuſtible. Diamond, an extremely fixed, tranſparent, inodorous, and infuſible ſubſtance, is perhaps the moſt combuſtible body known, as it burns entirely, without leaving any reſidue. Spirit of wine, æther, and ſeveral of the eſſential oils, are without colour.

2. Many bodies, upon loſing their phlogiſton, acquire new properties, which Stahl conſidered as depending upon that principle. Moſt metals, when calcined, aſſume a deeper colour; cobalt, mercury, lead, iron, copper, &c.

3. Stahl paid ſo much attention to combuſtible bodies,

dies, as he hoped, from the examination of their nature, to determine the character of phlogiſton, that he ſeems to have forgotten that air is eſſentially neceſſary to combuſtion. In conſequence of this, he has overlooked this objection againſt his theory, which was not indeed urged againſt him by any contemporary chemiſt. If combuſtion be nothing but the diſengagement of phlogiſton, it is plainly an act of decompoſition, in which the combuſtible body loſes one of its principles: But how is it poſſible for a body, after having loſt one of its component principles, to poſſeſs conſiderably more abſolute weight than before? An hundred lib. weight of lead affords an hundred and ten of minium; the weight of the ſulphuric acid obtained by the combuſtion of ſulphur, is greater than that of the ſulphur from which it was obtained: and, in the ſame manner, we learn from the fine diſcovery of M. Lavoiſier, that eighteen ounces of pure water are obtained by burning ſixteen ounces of ſpirit of wine *.

The ſtrength of this objection, together with the difficulty that is found in every attempt to demonſtrate the exiſtence of phlogiſton, have induced ſome modern chemiſts to deny that there is ſuch a ſubſtance in nature. But they muſt not be implicitly liſtened to; even that numerous train of experiments which have been of late made on combuſtible bodies and combuſtion, have not fully demonſtrated that there is no ſuch principle as fixed fire in material bodies: its exiſtence ſeems to be allowed, while its name is changed; and inſtead of the phlogiſtic, it is called the *caloric*, principle. It is diveſted,

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* Meeting of the Royal Academy of Sciences on the 4th of September 1784.—F.

veſted, however, of the property of producing combuſtion; and though it be acknowledged to exiſt in inflammable bodies, it is not conſidered as the cauſe of their inflammability.

Since chemiſts began to inquire how far the preſence of air is neceſſary to combuſtion, they have made ſeveral important diſcoveries; the chief of which is, that a certain quantity of atmoſpheric air is always abſorbed by burning bodies, and that it is the acquiſition of this air, which becomes fixed or combined, that augments the abſolute gravity of metals, ſulphur, phoſphorus, inflammable gas, and ſpirit of wine, when expoſed to combuſtion. As this increaſe of gravity has been likewiſe found to correſpond preciſely with the weight of the air abſorbed, ſeveral chemiſts, at the head of whom may be reckoned Meſſrs Lavoiſier and Bucquet, were led to adopt a new theory, founded ſolely on this abſorption of air, in which they entirely rejected phlogiſton. This theory was directly oppoſite to Stahl's, and conſiſted of the four following principles:

1. Stahl's phlogiſticated bodies are, according to this doctrine, ſubſtances which have a ſtrong tendency to combine with air; for on this tendency the combuſtibility of bodies entirely depends.

2. All the phenomena which Stahl aſcribed to the diſengagement of phlogiſton are produced by combinations with pure air: ſuch are combuſtion, calcination, reſpiration, and the formation of the ſulphuric and phoſphoric acids, by the combuſtion of ſulphur and phoſphorus.

3. On the other hand, according to the pneumatic theory, all thoſe phenomena in which the doctrine of

Stahl repreſents the phlogiſtic principle as entering into new combinations, are produced by the diſengagement of air. Such are the reduction of metals, effected by the mutual action of metallic calces and charcoal, the decompoſition of acids by combuſtible bodies, and particularly the decompoſition of the ſulphuric and nitrous acids by iron, charcoal, &c.

4. This theory views all thoſe bodies which Stahl thought to be compounds, with phlogiſton for one of their principles, as ſimple ſubſtances, having ſo ſtrong an affinity with pure air, that they attempt to enter into combination with it whenever they are expoſed to its contact. Combuſtion is, therefore, nothing but the combination of air with the combuſtible body; and all operations in which bodies are thought to regain their phlogiſton, are merely the diſengagement of pure air, or its paſſing out of one body into another."

This opinion, which was adopted by M. Bucquet in his latter courſes of lectures, explains indeed moſt of the phenomena of combuſtion, calcination, and the reduction of metallic calces; but it does not entirely explain why flame is ſeen to proceed from combuſtible bodies in a ſtate of ignition; nor does it account for the rapid motion produced in inflammation; and the other changes which attend this phenomenon. Macquer, after carefully examining how far the modern diſcoveries could affect the received theories, was of opinion that they were inſufficient to explode the theory of Stahl, and has therefore combined the pneumatic with the phlogiſtic doctrine, by repreſenting phlogiſton as light in a ſtate of fixation. After ſhowing that pure light, ſuch as that which the ſun diffuſes over our globe, may be conſidered as the ſubſtance of fire, and, by being fixed in bodies, may actually conſtitute the phlogiſton of Stahl; he next gives it as his opinion, that in every act of combuſtion, pure air diſengages the light or phlogiſton of combuſtible bodies, and poſſeſſes itſelf of its place; and that the calcination of metals may therefore be regarded as the precipitation of air, and the diſengagement of light. Again, when phlogiſton is reſtored to the calces of metals by reduction, light, in its turn, diſengages or ſeparates the air which was fixed in thoſe ſubſtances, and by that means cauſes them to reſume the character of metals. Macquer alſo thought; and it was neceſſary to his theory, formed with a view to reconcile Stahl's with the modern doctrine; that phlogiſton may combine with bodies even in cloſe veſſels, ſince light is well known to penetrate through glaſs, and even through metal and earthen veſſels, when theſe are made red-hot. Scheele has propoſed a different theory, which has alſo been adopted by ſome northern chemiſts. He conſidered fire, heat, and light, as compounds of vital air with phlogiſton; and thought that light in paſſing through veſſels, ſuffered decompoſition, the phlogiſton in the reduction of metallic calces or oxides being communicated to the calx, while the vital air was diſengaged. But this ingenious theory, by which Scheele accounted for the effects of ſolar light, and of the various modifications of heat on a great many chemical phenomena, affords no explanation of the increaſe of the weight of metals, ſulphur, and phoſphorus, &c. after combuſtion.

M. Lavoiſier, whoſe experiments have contributed ſo highly to the advancement of chemiſtry, and whoſe opinion

pinion muſt therefore have conſiderable weight, has propoſed a new theory that has been adopted by moſt French chemiſts, and appears to me to afford an happier explanation of the phenomena of Nature than any other. He thinks that light, heat, and all the other remarkable phenomena of combuſtion, depend rather on a certain action of the air than on the peculiar nature of combuſtible bodies; that the flame which then ariſes is occaſioned by the diſengagement of the light which was combined with the pure air, not of that which exiſted in the combuſtible body. He aſcribes to pure air that decompoſition which, according to Stahl and Macquer, takes place on the inflammable ſubſtance. Pure air he conſiders as a compound of the ſubſtance of fire and another principle which ſhall be afterwards deſcribed; and the fixed fire, the diſengagement of which is the principal act on ſuch occaſions, is, in his opinion, ſeparated from the pure air, not from the combuſtible body. We cannot enter more particularly into this ingenious ſyſtem in this place. In the hiſtory of air, in the following chapter, it will come more properly under our examination. At preſent we ſhall content ourſelves with obſerving, that the fire or heat, which M. Lavoiſier allows as a principle of pure air, and the diſengagement of which he takes to be the cauſe of the ſparkling flame and vivid heat which accompany the rapid combuſtion produced by that air, act nearly the the ſame part with Stahl's phlogiſton, or Macquer's fixed light; and that chemiſts ſeem to have univerſally agreed concerning the exiſtence of this principle, the only difference among them being, that one party believe it to exiſt in combuſtible bodies, and to be the cauſe of inflammability; while another conſider it as a principle of air, and aſcribe inflammation to a different cauſe. In the following chapters, we ſhall explain the reaſons which induce us to prefer the latter of theſe opinions.

§ V. *The Effects of Heat on Bodies conſidered Chemically.*

In the third ſubdiviſion of this chapter, it was ſhown that one of the chief effects of heat is to rarefy bodies, to increaſe their bulk, and diminiſh their ſpecific gravity, by ſeparating their particles, and enlarging their pores. Such was the ſimple phyſical or mechanical idea which we gave when ſpeaking of rarefaction in general; but when we attend more carefully to this primary act of heat, we ſhall find that it produces ſeveral other important effects.

The firſt and moſt ſtriking effect of heat, is its diminiſhing the aggregation of bodies, by ſeparating their particles. As the force of aggregation, and that of the attraction of compoſition, are always in the inverſe ratio of one another, as has been ſhown in the third chapter, it will be readily underſtood that heat, in deſtroying aggregation, muſt be ſingularly favourable to combination. This has cauſed fire to be conſidered as the principal chemical agent, and has even induced chemiſts to aſſume the title of *philoſophers by fire*. It will afterwards appear, however, that they make much leſs uſe of it at preſent than they formerly did.

The action of heat, when conſidered in this point of view, as tending to deſtroy aggregation, and favouring combination, appears liable to four different modifications, according to the nature of the bodies on which it exerts its energy.

1. There are ſome bodies on which it produces no alteration, nor any effect but dilatation. Subſtances of this nature are unalterable and *apyrous*. Thus rock-cryſtal, however long expoſed to the utmoſt violence of fire ſuffers no alteration: it loſes neither its hardneſs nor tranſparency, and appears, after this aſſay, with all its former denſity and beauty. But there are very few ſubſtances ſo little alterable as rock-cryſtal.

2*dly*, Heat entirely deſtroys the aggregation of moſt bodies, cauſing them to paſs from a ſolid to a fluid ſtate. This phenomenon is named *fuſion*; the bodies on which it is produced are called *fuſible*. There are various degrees of fuſibility, from that of platina, which is extremely difficult to melt, to that of mercury which remains always in a fluid ſtate. When this fuſibility is carried to an exceſſive degree, it becomes volatilization. A body becomes volatile, or diffuſes itſelf through the atmoſphere, when it is cauſed to paſs, by a ſtrong rarefaction, from the liquid ſtate to that of an elaſtic fluid. It is then diſſipated by heat, and elevated in the atmoſphere, where it remains ſuſpended till cold reſtore to it part of its denſity and ſpecific gravity. Bodies which may be reduced to this ſtate are named *volatile*; thoſe incapable of it are, by way of oppoſition, called *fixed*. There are many degrees between fixity and volatility. It even ſeems impoſſible to ſuppoſe any body abſolutely fixed. Perhaps the only reaſon why any appear ſo, is, becauſe we cannot apply to them a degree of heat ſufficiently intenſe. We may make the ſame remark on infuſibility; it is never abſolute. The reaſon why rock cryſtal appears infuſible, is; becauſe we cannot apply to it the proper degree of heat. When we ſpeak, therefore, of the infuſibility or the fixity of certain ſubſtances, we are to be underſtood as ſpeaking only in reference to the heat to which it is in our power to ſubject them.

This eſſential volatility is to be carefully diſtinguiſhed from that which is merely apparent, and takes place only in conſequence of the communication of motion by a current of flame or vapours: Thus, for inſtance, zink, in a ſtate of calcination, is carried up by the flame that is raiſed during its combuſtion.

3*dly*, When heat acts on bodies conſiſting of two principles, one volatile, the other fixed, it generally ſeparates them by volatilizing the former. Such bodies are thus decompoſed, but without ſuffering any alteration; for by reuniting their principles, we can reproduce them with all their original properties. This ſeparation of principles is a true or ſimple analyſis. Fire applied to bodies conſiſting of two ſubſtances, between which there is a wide difference in reſpect of volatility, reduces the volatile principle to vapours, but leaves the fixed uninjured. But in order that this true analyſis may take place, it is requiſite that both the volatile and the fixed principle of the compound be unalterable by the degree of heat applied to them; or that they be expoſed only to ſuch a degree of heat as they can bear without loſing any of their properties. The volatilized ſubſtance having then undergone no greater alteration than the fixed, they may be reunited ſo as to form the ſame compound which they conſtituted before their ſeparation. When this may be effected, the analyſis is true or ſimple. As bodies do not generally conſiſt of two principles, one of which is volatile the other fixed, and as it is often extremely difficult, and ſometimes even impoſſible, to apply to compounds of this kind preciſely that degree of heat which will volatilize the one without alteration, and leave the other uninjured; it may be naturally inferred, that the number of the bodies on which heat acts in this manner muſt be very inconſiderable. For this reaſon, chemiſts have now much leſs frequently recourſe to the operation of fire than formerly. The ſubſtances on which heat produces this effect are *decompoſible without alteration.* Some mineral ſubſtances, ſuch as cryſtallized ſalts and ſolutions of neutral ſalts, come under this claſs.

4thly, When the body expoſed to the action of fire conſiſts of ſeveral volatile and ſeveral fixed principles, the volatilized principles enter into mutual union; the fixed are alſo combined with one another: and ſuch is the reſult of this decompoſition, that though the products be reunited with the reſidues, the original compound will not be produced. This is, therefore, a falſe or complicated analyſis. The bodies on which heat acts in this manner are *decompoſable with alteration.*

Moſt natural ſubſtances belong to this claſs. They are too complex in their compoſition, and conſiſt of too many principles, to be decompoſed without ſuffering alteration. As the force of the affinity of compoſition acts upon all bodies, and is even promoted by heat, when any of the principles of a compound are volatilized by the action of fire, they react upon one another, unite, and form a new order of combination different from that in which they before ſubſiſted: the ſame thing takes place on the fixed principles of the body. Thus, when a piece of wood, bark, or any other vegetable ſubſtance, is expoſed to the action of fire; the water, the ſalts, and the oil, unite togther, and conſtitute an acid, elaſtic fluids, and a brown oil, &c. which did not exiſt in the wood in that form. The action of heat, therefore, produces a total alteration on ſuch ſubſtances: the phenomena which attend it indicate a falſe or complicated analyſis, the reſults of which might lead chemiſts into miſtakes were they not aware of the uncertainty with which it is attended. It is certain that art can never reproduce wood or bark, by mixing together the phlegm, oil, acid, and charcoal obtained in this analyſis; and that the principles which it affords have ſuffered great alterations. Unluckily the bodies ſuſceptible of theſe alterations are the more numerous claſs. Under it all animal and vegetable, and moſt mineral, ſubſtances are to be ranked. But the modern diſcoveries will enable us to determine the true nature of the principles of ſuch ſubſtances, by examining ſuch of them as are diſengaged.

Hitherto we have ſpoken only of the effects of ſuch a ſtrong heat as is uſually employed in the operations of art: But a gentle and continued heat, ſuch as that which is exerted in the operations of nature, gives riſe to a number of important phenomena, which are highly worthy of the chemiſt's attention. The vibration and oſcillation of the particles of ſolid bodies which its impulſe occaſions, and the agitation and rarefaction of fluids ariſing from the ſame cauſe, produce a continued internal motion which gradually changes the form, the dimenſions, and the contexture, of the former; and produces a ſenſible alteration on the conſiſtency, the colour, the taſte, and, in a word, on the intimate nature, of the latter. Such is the general idea which we have reaſon to form concerning the exiſtence and power of all the chemical phenomena of natural bodies; concerning the ſpontaneous decompoſition and recompoſition of minerals; concerning the cryſtallization, the ſolution, the formation of ſalts, the vitrification, the metallization, the vitriolization, and the mineralization, which are carried on in the bowels of the earth. To this powerful agent we muſt likewiſe have recourſe, when we attempt to form an idea of the alterations to which animal and vegetable ſubſtances are liable; of the motion of the ſap in plants, and the mild fermentation which conducts them to maturity; of the formation of oils, the ſpiritus rector, mucilages, and the colouring principle; or of the compoſition, the decompoſition, the reciprocal changes, and the putrefaction of animal humours. All theſe important phenomena depend, more or leſs, on chemical operations; and that heat which is diffuſed over the globe is the great principle by which they are produced. It is at preſent enough for us to have taken a general view of this great cauſe of motion, life, and death. We have here ſketched the outlines of the picture; in what follows we ſhall endeavour to fill them up with a nice and faithful hand.

As the various effects of heat depend all on its power of ſeparating the particles of bodies, let us farther conſider this firſt effect, and attempt to eſtimate its influence.

Water in the ſtate of ice is ſoftened by a certain degree of heat, melted, and reduced to fluidity by a greater, and by a ſtill greater degree reduced to vapour, or an elaſtic fluid: ſo that water in a ſtate of vapour may be ſaid to contain three ſums of heat;—that which conſtitutes ice of a certain denſity; that which reduces ice to the ſtate of a liquid, rarefied to a certain degree; and, laſtly, that which rarefies the liquid to an elaſtic fluid.

When we attempt to apply this theory to all natural bodies, they appear to be all capable of paſſing through theſe ſeveral ſtates if expoſed to a ſufficient heat. The only difference among them, in point of this property, is, that ſome may be reduced by a leſs degree of heat while others require a greater. It is only for want of ſufficient heat that we cannot reduce rock-cryſtal to a liquid or a vaporous ſtate: nor is it more difficult to conceive the poſſibility of this event, than to conceive an habitually elaſtic fluid, ſuch as air, acquiring an extreme ſolidity, as happens to this very ſubſtance in various combinations.

From theſe principles, it is eaſy to explain the formation of the elaſtic fluids which are diſengaged in many of the operations of nature and art. It uniformly happens, whenever a body receives and abſorbs a ſufficient quantity of heat to cauſe it to paſs into that ſtate of fluidity which conſtitutes an aëriform fluid; and therefore all fluids that poſſeſs this property owe it to heat. But it is alſo requiſite, that the preſſure of ſurrounding bodies, eſpecially the preſſure of air, do not oppoſe this extreme dilatation; or that the dilatation be ſo great as to overcome the reſiſtance which it meets with in the gravity of the air. Hence a body,

whether

whether nearer to or more diſtant from the ſtate of elaſtic fluidity, may be eaſily reduced to this ſtate by relieving it of the preſſure of the atmoſphere, as elaſtic fluidity always takes place *in vacuo*. Hence evaporation is moſt quick and copious on the tops of lofty mountains. And hence too it becomes neceſſary to mention preciſely, in a detail of experiments, with what degree of preſſure any body was reduced to an elaſtic fluid, or at leaſt what preſſure it can bear in that ſtate; for it is alſo to be obſerved, that all the bodies which can, with more or leſs eaſe, be reduced to the ſtate of vaporous or elaſtic fluidity, do not maintain themſelves in that ſtate with equal conſtancy; nay, ſuch are the differences among them in this reſpect, that they have been divided into *permanent* and *non-permanent*. The former remain long in the ſtate of elaſtic fluidity; nor do they paſs from it, till by ſome new combination they are deprived of the ſubſtantial heat by which they were maintained in that ſtate. The latter, which may be denominated vapours, loſe their elaſtic fluidity by degrees of preſſure or cold which may be eaſily eſtimated, and readily communicate to ſurrounding bodies that portion of heat which conſtitutes them aëriform fluids. Of this kind are water, alcohol or ſpirit of wine, and æther; theſe three fluids are reduced into vapours, and remain in that ſtate when the barometer ſtands at 28 inches,—water at 212° Fahrenheit, ſpirit of wine at 180°, 30′, and æther at 104°, &c. It appears then, *1ſt*, That the ſtate of elaſtic fluidity is a mode of the exiſtence of bodies occaſioned by the combination of heat with their other principles: *2dly*, That every elaſtic fluid is a compound, conſiſting of a baſe of more or leſs ſolidity, and the matter of heat: 3*dly*, That the baſe of every elaſtic fluid requires a certain degree of heat to reduce it to vapour or elaſtic fluidity; and that it is doubtleſs in conſequence of their poſſeſſing theſe properties, that elaſtic fluids differ in gravity, elaſticity, &c.

M. Lavoiſier has explained this theory with great perſpicuity, in a memoir printed among the Memoirs of the Academy of Sciences for 1777.

Although we have diſtinguiſhed elaſtic fluids into permanent and non-permanent, yet it is to be obſerved, that this diſtinction exiſts not in nature. It is relative to the moderate heat and preſſure of the atmoſphere to which we are expoſed in the climates in which we live, and over many parts of the globe; and if the cold and preſſure were more conſiderable, even the fluids which we at preſent conſider as the moſt permanent, would ſoon ceaſe to be ſo; and, on the contrary, æther and ſpirit of wine would become permanent elaſtic fluids at a certain height in the atmoſphere, or in the warm temperature of the equatorial climates.

As the ſubſtance of heat, which contributes to the formation of elaſtic fluids, exiſts in them in a combined or *latent* ſtate, and becomes not perceptible to our ſenſes till thoſe bodies loſe their fluidity by entering into combination with other ſubſtances; we have therefore ſought for an expreſſion proper to denote heat in this ſtate, and have adopted the word *caloric* for this purpoſe; becauſe in this ſtate heat may be actually conſidered as having loſt its original character, which it recovers not till it be reſtored to a ſtate of liberty. Beſides, by affixing to it this denomination, we avoid the circumlocutions of the ſubſtance or matter of heat, or latent heat, which have been hitherto applied to it. Cooling, or the paſſing of heat into the ſtate of caloric, and ignition, or the paſſing of caloric into the ſtate of heat, depend both on the general law above laid down, that when bodies become more denſe, part of their heat is exhaled. Thus, whenever a gas or aëriform fluid is combined ſo as to become a liquid or a ſolid, it loſes a great part of its ſubſtantial heat; and to make it paſs into that ſtate of denſity, it muſt be expoſed to the action of ſome body, with which its baſe has a greater affinity than with heat. This is the general cauſe of the fixation of elaſtic fluids; and in this manner do they loſe that form by becoming fixed in liquid or ſolid bodies. We may likewiſe obſerve that each of theſe fluids loſes more or leſs heat in proportion as it becomes more or leſs ſolid in the new combination, or in proportion as this compound body is capable of containing leſs or more ſpecific heat. This obſervation explains why bodies burn with different degrees of rapidity; why they give during combuſtion more or leſs flame or heat; and why the reſidues which they leave are more or leſs ſolid, &c.; which phenomena ſhall be more particularly mentioned in the following chapter.

Laſtly, Since cold and preſſure are the two means by which elaſtic fluids are condenſed, we may perhaps be at length able, by employing intenſe degrees of both, to reduce all theſe from their gaſeous ſtate, and to obtain their baſes pure and ſeparate, by expelling the ſubſtantial heat which maintains them in fluidity. Thus we may come to know the baſes of vital air, azote, *nitrogene*, or mephitic gas, hydrogenous gas, &c. This has been already performed on the ſulphureous acid gas, which M. Monge has reduced to a liquid by means of an intenſe cold.

§ VI. *Of Heat as a Chemical Agent, and the ſeveral Ways in which it may be applied to Bodies.*

Chemists employ heat, on account of the changes which it produces on bodies, both for decompoſition and combination. Their firſt object ſhould be to meaſure exactly the degrees of heat neceſſary to produce all poſſible alterations on any body expoſed to it. Theſe degrees of heat are generally ranked under two claſſes; the firſt comprehending all degrees of heat below that of boiling water; the ſecond, all above that temperature. The ſcale of the thermometer marks out the former; our only means of determining the latter is the known fuſibility of bodies.

Degrees of Heat below the point of boiling Water.

The firſt degree extends from 43° 15', to 54° 30', Fahrenheit's ſcale. This temperature promotes putrefaction, vegetation, and gentle evaporation, &c. It is but ſeldom employed in chemical operations, as being too inconſiderable; in ſome macerations made during winter, however, it is neceſſary. It is likewiſe uſeful for the cryſtallization of ſaline ſolutions, which after a proper evaporation are put into caves, or other places of this temperature.

The ſecond of theſe degrees, extending from about 65° 45', to 77°, continues to promote putrefaction, excites a ſpirituous fermentation in ſaccharine liquors, and is favourable to evaporation and ſlow cryſtallization. This is the uſual temperature of mild climates. It is employed for maceration, the ſolution of ſaline ſubſtances, and fermentation, &c.

The third diviſion or degree extends from about 88° 15′, to 99° 30′. It excites the acid or acetous fermentation in vegetables; and is ſufficient for the exſiccation of plants. It is uſed to effect ſome ſolutions of ſalts, and to produce fermentation.

The fourth degree, which riſes to 133° 15′, is called the mean degree of hot water: this is the heat uſed in the veſſels called *balnea mariæ*. It deſtroys the organization of animal ſubſtances, and volatilizes the ſubtler part of animal oils, more eſpecially of the ſpiritus rector. It is employed in the diſtillation of thoſe vegetable and animal ſubſtances, of which we wiſh to obtain the phlegm and the odoriferous part.

The temperature of boiling water 212°, is uſed in decoctions, and the extraction of eſſential oils.

Degrees of heat above the boiling point.

THE firſt degree or diviſion makes glaſs red, burns organized ſubſtances; and melts ſulphur.

The ſecond melts the ſofter metals, tin, lead, biſmuth, and ſuch glaſſes as are moſt eaſily reduced to a ſtate of fuſion.

The third effects the fuſion of moderately hard metals, ſuch as zink, regulus of antimony, ſilver, and gold.

The fourth burns porcelain, and melts the more refractory metals; cobalt, iron, and copper, &c.

The laſt and moſt intenſe degree exiſts in the focus of a burning-glaſs. This temperature calcines, burns, and vitrifies in an inſtant, all bodies ſuſceptible of combuſtion, calcination, or vitrification. A ſimilar heat may be excited by pouring from a blow-pipe a ſtream of vital air or oxigenous gas upon a piece of coal. M. Monge is of opinion, that by preſenting to combuſtible bodies, when in a ſtate of inflammation in a furnace, a quantity of compreſſed atmoſpheric air, the ſame effect might be accompliſhed which is produced by vital air. This proceſs may be one day or other applied to very important purpoſes.

Though theſe degrees above the heat of boiling water be determined by phenomena which are well known to chemiſts, yet they have not hitherto been meaſured with all the preciſion that could be wiſhed. It is therefore an object of the utmoſt importance to obtain an inſtrument capable of pointing out the exact degrees of heat employed in theſe operations. Mr. Wedgewood in England has conſtructed a thermometer for this purpoſe: it conſiſts of ſmall pieces of clay half an inch in diameter. Theſe pieces, when contracted by the heat, fall between two graduated rulers of copper inclining towards each other upon a plate of the ſame metal; and thus ſhow what contraction they have ſuffered, and of conſequence to what degrees of heat they have been expoſed (*Jour. de Phyſ. Ann.* 1787[*].)

The heat neceſſary in chemical operations is produced by burning charcoal, or common mineral coal. We uſe on theſe occaſions furnaces of different forms and names, according to the different purpoſes for which they are intended; ſuch are the furnaces for digeſtion and fuſion, the reverberating furnace, the wind furnace, and the cupelling furnace. A ſingle furnace, properly made, is often ſufficient for the purpoſes of all theſe; and it is then called a *Polychreſt furnace.* The reader may conſult on this head the Chemical Dictionary of Macquer, who has contrived a moſt excellent and uſeful furnace; Baumé's Chemiſtry, Pott's Lithogeognoſia, and Abbé Rozier's *Journal de Phyſique*, in which there are deſcriptions of various furnaces conſtructed by different chemiſts. The flame of oil, or ſpirit of wine, is alſo employed ſometimes in lamp-furnaces adapted to the purpoſe.

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[*] There is an accurate deſcription of this ingenious contrivance, by the inventor himſelf, in the Engliſh Philoſophical Tranſactions for 1782.—H.

The manner in which fire is applied to bodies in chemical proceſſes, likewiſe deſerves ſome explanation. If the combuſtible body be applied immediately to the ſubſtance on which you wiſh the fire to act, the operation is then ſaid to be managed with *naked fire.* But ſome intermediate body is often put between the fire and the ſubſtance expoſed to its action; hence the names *balneum mariæ*, ſand-bath, cinder-bath, dung-bath, &c.

The form of the veſſels made uſe of in ſubjecting bodies to the action of fire, and the various phenomena exhibited by bodies under the influence of heat, have cauſed a great variety of operations to be diſtinguiſhed by peculiar names. Such are roaſting, calcination, fuſion, reduction, vitrification, cupellation, cementation, ſtratification, detonation, decrepitation, fulmination, ſublimation, evaporation, diſtillation, rectification, concentration, digeſtion, infuſion, decoction, lixiviation. All theſe operations are performed by the action of fire, and enter into the practice of chemiſtry;

and we ſhall therefore give a ſhort explanation of each of them.

Roaſting is a preliminary operation, which prepares mineral ſubſtances for undergoing a ſeries of ſucceeding ones, dividing their conſtituent particles, volatilizing ſome of their principles, and producing a certain alteration on their nature. Mineral ores are expoſed to this proceſs on purpoſe to ſeparate the ſulphur and arſenic which they contain, and to diminiſh the coheſion of their particles. Capſules of earth or iron, crucibles, and roaſting pots, are the veſſels in which it is uſually performed; and it is generally expoſed to the acceſs of the external air. Sometimes, however, the operation is performed in cloſe veſſels; and two crucibles, luted mouth to mouth, are commonly employed on ſuch occaſions.

Calcination is, as it were, a more advanced ſtage of the proceſs of roaſting. By this proceſs minerals are deprived of their water and ſalts; it likewiſe reduces calcareous ſubſtances to the ſtate of quick-lime, and metals to metallic oxides. The ſame veſſels are uſed in this proceſs as in the former.

In fuſion, a body is cauſed to paſs by fire from a ſolid to a fluid ſtate. The chief ſubjects ſuſceptible of this operation are ſalts, ſulphur, and metals. Crucibles of baked clay of various kinds and figures, with metallic cones and ingot moulds, are the inſtruments for this operation. Theſe laſt are employed to give the melted matter a certain form; which they mould into bars, ingots, or buttons.

In reduction or revivification, the calces of metals are, by means of fire, with charcoal or oils, reſtored to the metallic ſtate which they loſt by calcination.

Vitrification is the fuſion of ſuch ſubſtances as are capable of aſſuming the brightneſs, tranſparency, and hardneſs of glaſs. Vitrifiable earths with alkalis, and the oxides of metals, are the chief of the ſubſtances ſubjected to it.

Cupellation is the purifying of perfect metals, by the extraction of ſuch imperfect metals as are intermixed with them. This is performed by the addition of a certain quantity of lead to the mixture, and the expoſing of it to a due heat; which vitrifies the lead, and together with it the imperfect metals of the original mixture, leaving the perfect in a pure and ſeparate ſtate. This operation derives its name from the veſſels uſed in it. Theſe are a kind of flat crucibles, reſembling the ſmall cups known under the name of *cupels*; and the ſubſtance of which they are compoſed, being the earth of bones, is ſufficiently porous to abſorb and retain the lead that is ſcorified by the heat.

The name of *cement* is given to powdered ſubſtances, with which other ſubſtances expoſed to their action are carefully covered over. Thus, iron is covered over with powder of charcoal, that it may be converted into ſteel; and glaſs with plaſter or ſilex, to change it into a kind of porcelain. The proceſs by which this is effected is cementation, and requires the action ſometimes of a very ſtrong fire.

Stratification is an operation nearly ſimilar to the preceding. It conſiſts in arranging ſeveral ſolid ſubſtances, uſually in in horizontal layers, and intermixed with certain pulveriſed bodies, to alter their nature, either in a crucible or in ſome other ſuitable veſſel capable of bearing the action of fire. This has received the name of *ſtratification*, becauſe the ſubſtances are diſpoſed in ſtrata or layers, one riſing above another. Copper and ſilver are treated in this manner with ſulphur, in order to effect their combination. This peculiar arrangement of ſubſtances, named *ſtratification*, is often employed preparatory to fuſion, calcination, vitrification, &c.

Detonation is peculiar to nitre and the mixtures into which it enters. It is the exploſion of ſuch bodies when heated in open or cloſe veſſels. Decrepitation differs from detonation only as producing a fainter noiſe, which is merely a kind of crackling ſound; it is peculiar to certain ſalts; which from a ſtate of ſolution are cryſtallized ſo rapidly, that the cryſtals formed burſt into minute pieces. This has been obſerved chiefly of common ſalt, or muriate of ſoda. Fulmination is a a more quick and lively detonation; ſuch as takes place on fulminating gold, fulminating powder, and in the combuſtion of inflammable gas and vital air, &c.

Sublimation is the volatilizing of dry, ſolid, and often cryſtallized ſubſtances by means of fire. The veſſels, uſed in ſublimation are glazed earthen pots, earthen crucibles with glaſs heads, and pots of earth or porcelain, arranged one above another, and joined by the inſertion of their necks one into another, which are known by the name of *aludels*, &c. Sulphur, arſenic, cinnabar, many mercurial preparations, ſome vegetable ſubſtances, more eſpecially camphire and flowers of benzoin, are the ſubjects of ſublimation.

Evaporation is the action of heat on liquids, to diminiſh their fluidity and quantity, and to obtain the fixed bodies diſſolved them in a ſeparate ſtate. Thus, we evaporate the water of the ſea and of ſalt ſprings, in order to obtain the ſalt which they contain. This operation is performed in capſules, jars, earthen or glaſs evaporatories, and ſilver pans, according to the nature of the liquid to be evaporated. The evaporating ſubſtance is expoſed to the contact of the air, in order that the water, the body to be carried off by volatilization, may diffuſe itſelf through the atmoſphere, and that the air by its ſolvent power may promote the evaporation.

Diſtillation is an operation nearly ſimilar, but performed in cloſe veſſels. It is uſed to ſeparate volatile from fixed principles by means of fire. The diſtillatory veſſels are alembics and retorts. The firſt conſiſt of a lower veſſel named a *cucurbite*, intended to contain the body to be diſtilled, and an upper part or capital exactly fitted to it; the purpoſe of which is to receive the volatilized ſubſtance, and condenſe it by the coldneſs of its temperature (which is maintained by the contact of the external air, or of water ſurrounding it); when water is uſed, the veſſel containing it, into which the upper part of the alembic is immerſed, is called a *cooler*, or *refrigeratory*. From the lower part of the capital there proceeds a kind of beak or ſpout, through which the vapours paſs into a pipe, where they are condenſed into a liquid: from this pipe the liquid thus obtained is conveyed into other veſſels, which are commonly of a ſpheric form, and are named *receivers*. Theſe receivers are of various forms and names, matraſſes, balloons &c. A retort is a kind of glaſs, ſtone, or metal bottle, of a conical form, with its extremity bent, ſo as to make an acute angle with its body; and on this account, has it received the name *retort*. Diſtillation has been rather improperly diſtinguiſhed into three kinds, namely, diſtillation aſcending, *per aſcenſum;* diſtillation deſcending, *per deſcenſum;* and lateral diſtillation, *per latus*. This diſtillation is warranted only by the exterior form of the veſſels made uſe of. The volatilized matter has always a tendency to aſcenſion: But diſtillation performed in glaſs or metal alembics has received the peculiar denomination of *aſcending*, becauſe the capital is placed over the cucurbite, and the vapours are ſeen to aſcend. The diſtillation performed in retorts is called *lateral*, becauſe the beak or neck of that veſſel comes out at the ſide of the apparatus; but the cavity of the retort in which the vapours are condenſed is higher than its neck, and the diſtilled ſubſtance paſſes through that cavity, before reaching the neck. As to diſtillation *deſcending*, it was an operation which ſcarce ſerved any purpoſe, and is now no longer uſed; its products were always in a very bad ſtate, and great part of them was loſt in the proceſs. It was performed by ſpreading a piece of cloth over the mouth of a glaſs, placing upon it ſome vegetable ſubſtance, and covering this with the ſcale of a balance, or with a capſule of metal containing ſome live coals. This mode of diſtillation was formerly uſed in pharmacy and perfumery, for obtaining the eſſential oils of ſome odoriferous ſubſtances. The product paſſing through the cloth dropped into the glaſs, which was always half full of water, to cool the oil; but moſt part of the eſſence was always loſt on the cloth and the metal plate above. A more uſeful diſtinction is that which regards the manner in which the ſubſtances to be diſtilled are warmed. This is performed either with the *balneum mariæ*, by dipping the cucurbite in boiling water, or with the vapour, the ſand, or the cinder-bath, or with naked fire. It is alſo effected by means of the flame of a lamp, and by that of ſpirit of wine.

Rectification is a ſecond proceſs of diſtillation, the object of which is to purify a liquid ſubſtance. In it, heat is employed to carry off the pureſt and moſt volatile part, leaving the more fixed matter, which debaſed it, in a ſeparate ſtate; as is done, for inſtance, with ſpirit of wine, æther, &c.

Concentration is the direct contrary of rectification; its object being to volatilize part of the water, and thus improve the ſtrength of the fluids concentrated. The matter to be concentrated therefore muſt be of ſuperior gravity to water. This operation is performed on ſome acids, particularly on the ſulphuric and the phoſphoric; it is alſo employed in ſolutions of alkalis and neutral ſalts.

Digeſtion is the expoſing of ſubſtances which we wiſh to act gently on one another to a gentle and long continued heat. It is chiefly uſed to extract thoſe parts of vegetable ſubſtances which are ſoluble in ſpirit of wine or other fluids. Chemiſts formerly put great confidence in this operation. Though that confidence ſeems to have been juſtly due, as it appears from many painful reſearches, that too active or too rapid a fire alters the nature of moſt vegetable and animal ſubſtances; yet modern chemiſts do not depend on this proceſs with the ſame enthuſiaſm as the alchemiſts of old. The patient induſtry of theſe men was often employed for a ſeries of years on one proceſs of digeſtion: for by ſuch proceſſes they expected to perform wonders. Digeſtion is now confined to dyeing ſtuffs, elixirs, and liquors for the table; it is always ſucceſsfully employed to extract the principles of vegetables and animal matters, without altering them. It is likewiſe uſeful in ſeveral operations in minerals.

Infuſion is a well-known proceſs: it conſiſts in pouring warm or boiling water on ſubſtances of which we wiſh to extract the moſt ſoluble parts, and of which the contexture is ſo ſlight as to be eaſily penetrable, ſuch as thin bark, wood in ſmall thin pieces, leaves, flowers, &c. It is of great uſe for ſeparating ſubſtances that are eaſily ſoluble, and is often employed in chemical operations.

Decoction, or the continued ebullition of water with ſubſtances on which it acts, is uſed to ſeparate thoſe parts of bodies which are not ſoluble by a more moderate degree of heat. It produces conſiderable alterations on vegetable and animal matters; often effecting an entire change of their properties. It coagulates the lymph, melts greaſe and roſin, and hardens the fibrous parts of a vegetable or animal. When the chemiſt is well acquainted with its effects, he may employ it with conſiderable advantage.

In the proceſs of lixiviation, we diſſolve, by means of warm water, the ſaline and ſoluble particles of cinders, the reſidues of diſtillation and combuſtion, coals, and ſuch natural earths as we wiſh to analiſe. This operation very naturally derives its name from the *lixivial* ſalts which are obtained by means of it. The word *leſſive* is at preſent uſed in France as ſynonymous with *lixiviation*, and is even more frequently uſed. This operation, then, is merely a ſolution effected by means of

heat:

heat: it is likewiſe nearly ſimilar to infuſion; the only difference is, that the latter is applied to vegetable and animal matters; while lixiviation is only employed to obtain ſubſtances poſſeſſing ſome of the properties of minerals.

Theſe are all the operations in chemiſtry in which fire is called in to act a part. Formerly, indeed, no chemical operation was performed without the help of this agent: and the ſcience was on that account named *Pyrotechny*. But as methods of analiſing bodies have been ſince diſcovered which are much leſs liable to error and more certain in their reſults; the agency of fire is now much leſs uſed in chemiſtry than formerly. The action of ſolvents, or menſtrua, employed in a cold ſtate, or in the ordinary temperature of the atmoſphere, is often ſufficient to accompliſh the moſt ſurpriſing changes on natural bodies, and affords ground for the moſt accurate inductions. This method has been applied to the examination of ſalts, earths, and vegetable matters, &c. with the happieſt ſucceſs. Heat is no more than a ſecondary mean, a kind of auxiliary that affords ſome aſſiſtance on ſuch occaſions. As different degrees of heat are requiſite in different operations, it would be a happy circumſtance if ſome means were contrived, by which we might be enabled to apply always the ſame preciſe degrees of heat when the ſame effects were wanted. Chemiſts and philoſophers have long wiſhed for a furnace which might afford regular and uniform degrees of heat: Hitherto, however, the manipulations of artiſts have given the only means that can in any degree ſerve that purpoſe. But perhaps it is not impoſſible to obtain that preciſion which we deſire, and of which the utility is ſo obvious. Dr Black is ſaid to have invented a kind of furnace, by which he can command a regular and uniform heat by means of a damping-plate with holes, which may be opened or ſhut at pleaſure. We have not received a ſufficiently accurate deſcription of it, to enable us to conſtruct any on the ſame model. But we hope that a diſcovery ſo beneficial to chemiſtry will not be long unknown in France *.

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* For meaſuring HEAT with the accuracy which is requiſite for the purpoſes of ſcience, the following means and inſtruments have been employed.

1. Graduated glaſs tubes, filled with different ſubſtances which are rarefiable by heat, and named THERMOMETERS. Of theſe, the THERMOMETERS filled with mercury, have now almoſt ſuperſeded the uſe of thermometers filled with fluids. The THERMOMETERS the moſt commonly in uſe, are thoſe of *Fahrenheit*, *Reaumur*, and *Celſius*. The *thermometer of Fahrenheit* is that generally uſed in *Britain*. *Reaumur's thermometer* is commonly employed by the French philoſophers. A degree of *Fahrenheit's thermometer* is equal only to $\frac{4}{9}$ of a degree of *Reaumur's*; and to $\frac{5}{9}$ of a degree of *Celſius' thermometer*. To reduce the degrees of *Reamur*, to the degrees of *Fahrenheit*, multiply by 9, and divide by 4. To reduce the degrees of *Celſius* to thoſe of *Fahrenheit*, multiply alſo by 9, but divide by 5.

2. The well known pyrometer of Muſchenbroek.

3. Mr. *Leidenfroſt* having obſerved, that the hotter a metal is, ſo much the more ſlowly will drops of water evaporate from its ſurface; has applied this principle to the meaſurement of the higher degrees of *heat*. On *iron* heated to the degree of boiling water, a drop of water evaporates in *one ſecond*: On melted lead, in 6 or 7 *ſeconds*: On red-hot iron in 30 *ſeconds*. At 520° Fahrenheit, the hot body evaporates a drop of water in 89 ſeconds.

4. The pureſt clay ſhrinks in the fire, in proportion to the heat applied to it. And upon this principle, the ingenious *Mr Wedgewood* conſtructed one of the beſt *pyrometers* with which we are acquainted. It conſiſts of a graduated gauge; the rule of which is divided into 240 equal parts, each being $\frac{1}{10}$ of an inch;—and of other pieces of the ſame clay, baken in a red heat, and of given dimenſions, which are applied to the heat

to be meaſured, and are then again applied to the graduated gauge; which ſhows how much they have ſhrunk, and by conſequence affords a meaſure of the heat to which they have been expoſed.

5. The inſtrument of *Meſſrs. Lavoiſier* and *De la Place*, for meaſuring heat by the melting of ice, is perhaps more accurate than any other pyrometer. It conſiſts of three circular veſſels, nearly inſcribed in each other; and affording three ſeparate capacities, or receiving ſpaces. The *interior* cavity, formed by an iron grating, upon ſupports of the ſame metal, and cloſed on the upper part by a cover, is deſigned for the reception of the body ſubjected to experiment. The *middle* cavity contains the ice, the melting of which is to meaſure the heat given out by the body under experiment. The *exterior* cavity contains ice intended to preclude any heat out of the atmoſphere, from paſſing into the *middle* ice, which is to be melted by the heat of the *interior* body alone. The water produced by the melting of the middle ice is weighed; and its weight affords a meaſure of the heat given out.

For the deſcription of Dr. Black's furnace, ſee *the Edinburgh New Diſpenſatory*, 4th edition, pages 48, 49, 50, 51, with fig. 7, 8, 9, of Plate I.—H.

CHAP.

CHAP. VI.

Of Atmoſpheric Air.

COMMON air is an inviſible, inodorous, inſipid fluid poſſeſſed of gravity and elaſticity, extremely ſuſceptible of motion, and capable alſo of rarefaction and condenſation, which encompaſſes our globe to a certain height, and compoſes the atmoſphere. It likewiſe inſinuates itſelf into, and occupies, the interſtices or pores between the integrant parts of bodies. The atmoſphere which encircles our globe is far from being pure air. As it receives all the vapours that ariſe from the ſurface of the earth, it may be conſidered as a kind of chaos, or heterogeneous mixture. We ſhall ſoon ſee, however, that its nature is at preſent pretty well known. Water, mineral exhalations, and elaſtic fluids diſengaged from minerals and metals, are inceſſantly carried up into the atmoſphere, and may be ſaid to conſtitute its elements. The objects of attention in a natural hiſtory of the atmoſphere are, its height, the preciſe degree of which is not yet accurately determined; the variations to which it is liable; its gravity; its different ſtrata; the effects of its rarefaction and dilatation; winds, and meteors. But theſe come under that part of phyſics which is known by the name of *meteorology*, and form no part of the province in which we are engaged. Yet as air has a powerful influence on chemical phenomena, and it is of conſiderable importance to know the nature and extent of that influence, we ſhall here examine both the phyſical and the chemical properties of air.

§ I. *Of the Phyſical Properties of Common Air.*

Fluidity, inviſibility, inſipidity, gravity, elaſticity, and negation of ſmell, may be conſidered as the phyſical properties of air. Each of theſe merits a particular examination.

Such is the rarity of this fluid, that it readily yields to the ſlighteſt impulſe, changing its ſituation on the ſmalleſt motion of bodies immerſed in it. This kind of fluidity depends on the degree of its aggregative force; and as it is not confined to atmoſpheric air, but is found to characteriſe ſeveral other fluids, theſe are called *aëriform fluids*, or *gaſes*. What conſtitutes the peculiar nature of aerial aggregation, is, incapacity to paſs into a ſolid ſtate; contrary to what moſt liquid bodies are ſuſceptible of. But this, however, no more is to be underſtood, than that hitherto we have not been able to apply to it any degree of preſſure or cold ſufficient to accompliſh this effect. This is the diſtinguiſhing characteriſtic of permanent gaſes. The fluidity of the air expoſes it to thoſe frequent and rapid motions which conſtitute the winds. It is not, however, capable of penetrating into all bodies. Tranſparent matters, through which light readily makes its way, are ſecure againſt the impulſe of air. Water, ſolutions of ſalts, oils, and ſpirit of wine, paſs through many bodies whoſe contexture is ſuch as not to admit air. Thoſe liquid ſubſtances are endowed with the property of dilating ſuch bodies, enlarging their pores, and diminiſhing the cloſeneſs of their contexture; of which air is deſtitute.

Air, when confined in veſſels, is abſolutely inviſible, not to be diſtinguiſhed from the glaſs that contains it: even when entirely filled with this ſubſtance, phials preſent to the eye a ſeeming vacuum. It owes this property of inviſibility to its tenuity and the ready paſſage which it affords to the rays of light: theſe are refracted, without being reflected by it. And it is therefore deſtitute of colour; though ſome natural philoſophers have perſuaded themſelves that they diſcovered large columns of it to be blue.

Naturaliſts have uniformly conſidered air as an inſipid body. Yet, in attending to what happens, when the nerves of animals are expoſed to the contact of this fluid, as in the inſtance of wounds, and on other ſimilar occaſions, we cannot but obſerve that it has a kind of pungency; of which we are not generally ſenſible, only becauſe we are ſo conſtantly accuſtomed to it. Wounds, when uncovered and expoſed to the air, are affected with an acute pain. A new-born infant expreſſes by its cries the diſagreeable ſenſations which it feels from the firſt contact of the external air. This pungency of the air is to be conſidered as the reaſon why wounds that are expoſed to it, uncovered, remain ſo long open. Atmoſpheric air, in the ſame manner, impedes the growth of new bark on ſuch vegetables as have been ſtripped of their covering. In order that trees may regain their bark, they muſt be covered over with ſome body which may exclude the air.

Air is perfectly inodorous. If the atmoſphere ſometimes affect our organs with a kind of fetid ſmell, this is to be attributed to the extraneous bodies that are mixed with it; as may be obſerved in miſts and vapours.

The gravity of air is one of the fineſt diſcoveries of natural philoſophy: the fact was never certainly known till about the middle of the laſt century; though Ariſtotle indeed is ſaid to have known that a bladder was heavier when filled with air than when empty. The ancients had no diſtinct idea of the gravity of air, but aſcribed to a certain occult quality, which they called *abhorrence of a vacuum*, all thoſe phenomena which depend on the weight of this body. Certain workmen finding it impoſſible to raiſe water by a pump above the height of two and thirty feet, were induced to conſult the famous Galilæo on the occaſion. He was amazed at the phenomena. Death prevented him from diſcovering the reaſon of it; but this was afterwards diſcovered by his diſciple Torricelli in the following manner. He reflected, that water could not riſe in a ſucking pump, without being impelled by ſome exterior cauſe, the preſſure of which forced it to follow the motion of the piſton. The influence of that cauſe muſt be limited, ſince it never raiſed the water above the height of two and thirty feet. Therefore, if it were to act upon a body of greater ſpecific gravity than water, it would raiſe that body only to a height proportioned to its gravity. He next took a glaſs tube ſix and thirty inches in length, and hermetically ſealed at one end; this he filled with mercury, holding the cloſe end down, and ſtopping the upper end with his finger, after he had poured in the mercury: then, turning the cloſe end up, he immerſed the other into a veſſel full of mercury; and upon removing his finger, found that part of the mercury in the tube had fallen down into the veſſel, but that a conſiderable quantity ſtill remained; which after various oſcillatory motions, at length ſettled at 28 inches. By comparing this with the height of 32 feet, to which water roſe in the pumps, he perceived that the difference of the elevations to which theſe two fluids roſe was in exact proportion to the difference between their ſpecific gravities; for the proportion of the ſpecific weight of mercury to that of water is as 14 to 1, and the water roſe 14 times as high as the mercury. It was not, however, till after long reflection, that he began to conjecture the weight of the air to be the cauſe why fluids were thus ſuſpended in a pump. Nor was the exiſtence of this weight certainly determined, till after the ingenious experiment which Paſchal directed to be made in France.

This celebrated philoſopher imagined, that if it were actually the weight of the air which cauſed water to riſe to the height of 32 feet in a pump, and mercury to the height of 28 inches in Torricelli's tube, theſe fluids would riſe to different elevations on the ſummit of a mountain and in a vale; as in the former caſe the weight of the atmoſphere muſt be diminiſhed. In conſequence of this ſuggeſtion of Paſchal's, Perrier made the famous experiment which finally determined the opinions of philoſophers concerning this phenomenon, on the 19th September 1648, at the foot and on the ſummit of the mountain Puits de Dome, in Auvergne. The barometer, or Torricellian tube, being filled with mercury, and fixed to a ſcale of 34 inches, divided into inches and lines, the mercury roſe about four inches higher at the foot of the mountain than on its ſummit, which is 500 toiſes higher. From this it was determined that the mercury varied about an inch for every hundred fathoms: and the barometer has ſince that time been very ſucceſsfully applied to the meaſurement of the height of mountains.

The weight of the air has an influence on many phyſical and chemical phenomena. It compreſſes all bodies, and reſiſts their dilatation; it oppoſes the evaporation and volatilization of fluids: and to it the waters of the ſea owe their liquidity; for they would otherwiſe be reduced to vapour, as may be obſerved of fluids placed in the vacuum produced by the air-pump. Air, by its gravitation on our bodies, retains both the ſolids and fluids in their proper places: and the blood often burſts through the ſkin, or from the lungs, on the tops of mountains, occaſioning hemorrhagies; becauſe the gravity and preſſure of the air are there conſiderably diminiſhed.

Laſtly, air poſſeſſes great elaſticity. However ſtrongly compreſſed, it inſtantly returns to its former rarity aſſoon as the compreſſing cauſe ceaſes to act upon it. The truth of this aſſertion is proved by a great many experiments. We ſhall here mention only the moſt obvious and moſt concluſive of thoſe phyſical facts by which it is evinced. Take a tube of glaſs, bent into a form ſomewhat like the letter U, and cloſe at one end; fill it nearly up with air, and then pour in a quantity of mercury to prevent the air from eſcaping: you may thus compreſs the air ſo as to know what degree of compreſſion this elaſtic fluid is ſuſceptible of, by comparing the diminution of its bulk with the height of the column of mercury employed to compreſs it. A foot-ball, which being filled with air rebounds from any hard body, affords another proof of the elaſticity of this ſubſtance. The fountain by compreſſed air, gives an inſtance of the ſame fact: Air being compreſſed into the ſuperior part of this veſſel, is ſoon dilated by the heat of the atmoſphere, ſo as to force the water out by a tube to a conſiderable height. Laſtly, the wind-gun, the effects of which are generally known, is another inſtrument for ſhowing the elaſticity of air, and the compreſſion of which it is ſuſceptible. It is computed, that air may be compreſſed into $\frac{1}{110}$th of its ordinary bulk.

Heat, which rarefies it by counteracting any compreſſive force to which it is expoſed, ſhows that it is no leſs capable of enlarging its bulk by dilatation. If a bladder full of air be expoſed to the heat of a furnace, the air will be dilated ſo as to burſt the bladder with a violent exploſion. This is likewiſe often the cauſe of the burſting of the veſſels in chemical operations; againſt which, however, proper precautions are now adopted. The diminution or total abſtraction of the weight of the atmoſphere, which is effected by the air-pump, affects a bladder filled with air in the ſame manner as a violent heat.

The reader will naturally conclude from this account of the gravity and elaſticity of air, that many of the variations which we obſerve in the atmoſphere and on the barometer are owing to theſe properties. In fact, the inferior ſupport the ſuperior ſtrata of the atmoſphere;

moſphere; and the compreſſion of a ſtratum of air is always ſmaller or greater in proportion as it occupies an higher or lower ſituation. Heat alſo, which is conſtantly varying, has the power of modifying this gravity and elaſticity. Theſe are the reaſons why air is found to be lighter, keener, and more agitated, &c. on the tops of mountains, than on plains and other leſs elevated ſituations. To underſtand thoſe aſtoniſhing phenomena which the barometer offers to our attention, we muſt ſtudy the gravity and elaſticity of the atmoſphere, as well as the changes to which it is liable, from the influence of heat. M. de Luc and M. Sauſſure, have for ſome years paid much attention to this claſs of the phenomena of nature.

§ II. *Of the Chemical Properties of Common Air.*

The properties above deſcribed are all that were anciently conſidered by philoſophers as belonging to air. Several chemiſts, at the head of whom Van Helmont, Boyle, and Hales, deſerve to be ranked, obſerving that air, or at leaſt a fluid with all the apparent properties of air, was obtained in the analyſis of many natural bodies, inferred, that this element ſubſiſted in thoſe bodies in a combined and fixed ſtate. Hence aroſe the name *fixed air*, which was at firſt given indifferently to all the elaſtic fluids obtained in chemical operations. The above mentioned philoſophers ſuppoſed theſe ſubſtances to be of the ſame nature with atmoſpheric air: But Dr Prieſtley has diſcovered a number of elaſtic fluids, which, though apparently the ſame with common air, yet differ from it in many reſpects.

We muſt then have recourſe to other qualities, if we wiſh to diſtinguiſh atmoſpheric air from the other aëriform fluids, which like it are inviſible and elaſtic. Its chemical properties afford the only criterion on which we can eſtabliſh this diſtinction.

In examining the diſtinctive properties of air, we find two which are peculiar to it, and may very well ſerve to mark its character; one, its being favourable to combuſtion or inflammation; the other, its ſerving to maintain animal life in reſpiration. Let us carefully examine theſe two great phenomena.

It is exceedingly difficult to give a good definition of combuſtion. It is not one, but a number of phenomena which combuſtible bodies offer to our obſervation, when they are heated and expoſed to the action of the air. The chief of them are heat, motion, flame, redneſs, and the change of the nature of the ſubſtance that is burnt. There are many varieties among combuſtible bodies. Some of them burn briſkly, and afford a brilliant flame, ſuch as oils, wood, reſinous and bituminous ſubſtances, &c.: others burn away without producing a diſcernible flame; as for inſtance many of the metals, and charcoal which has been properly prepared: others again are conſumed by a ſlow motion, ſcarce obſervable, almoſt without ſeeming to be on fire, but always with a degree of heat;—ſuch is the combuſtion of ſome metallic matters. Combuſtion, however, takes place equally in all theſe inſtances; and the body which has been once burnt in any of theſe ways, is no longer ſuſceptible of inflammation. The reſidue is always heavier than the combuſtible body. This may be eaſily proved to be the caſe with fixed combuſtible bodies. But again, thoſe of which the inflammable matter is of a volatile nature, burn with more rapidity than the former, and their fixed reſidue wants much of the original weight. From this it may perhaps be thought, that theſe laſt loſe much of their weight in burning: but it is only a ſeeming loſs they ſuffer; and there are no combuſtible bodies of which the reſidues are not weightier than before combuſtion. For, what remains fixed on ſuch occaſions is not the only reſidue of the combuſtible body; a conſiderable part of volatile combuſtible bodies is converted into elaſtic fluids, which aſcend and are diffuſed through the atmoſphere: and were we to ſuppoſe that theſe leave no other reſidue but what appears after their combuſtion on the ſpot, or in the veſſel where they were burnt, we muſt believe what is impoſſible, that they afford no reſidue. Æther and ſpirit of wine burn away without leaving the ſmalleſt particle; but the ſubſtance into which they are converted is volatilized and diffuſed through the atmoſphere. When means are employed to collect it, it is found to poſſeſs more gravity than the combuſtible body from which it was produced. Thus, by burning ſixteen ounces of highly rectified ſpirit of wine under a chimney adapted to the worm-pipe of a ſtill, M. Lavoiſier obtained eighteen ounces of water as the product of this combuſtion. Oils, reſins, &c. preſent the ſame phenomenon. Thus, the cinders of burnt wood are not the whole of the reſidue which it affords, the reſt aſcends in the air: one part, not being thoroughly burnt, becomes ſoot; and the other mixing with the atmoſphere, is condenſed into water, or depoſites in it ſome other elaſtic fluids. It is therefore an eſtabliſhed truth in chemiſtry, that all combuſtible bodies acquire additional weight by being burnt.

To underſtand how this addition of weight is acquired, we muſt attend to another of the phenomena of combuſtion, which it will be neceſſary to explain more at large. Combuſtion can never take place without the help of air, and is always in proportion to the purity and the quantity of that fluid. Ever ſince the diſcoveries of Boyle and Hales, philoſophers have been ſtruck with this fact, and have propoſed a variety of hypotheſes to explain it. Boerhaave thought that air contributed to combuſtion by operating on the ſurfaces of combuſtible bodies, ſo as to diſſect them, if the expreſſion may be allowed, into their component particles. This hypotheſis did not explain why the ſame air could not always promote combuſtion. M. Morveau ſuppoſed this laſt fact to depend on the extraordinary rarefaction of the air by heat; in conſequence of which, it acquired ſuch elaſticity as to prevent the combuſtion of inflamed bodies by forcible compreſſion. But he offered this ingenious hypotheſis at a time when it was impoſſible to diſtinguiſh the true cauſe of the phenomenon. M. Lavoiſier, by a ſeries of fine experiments on the calcination of metals with determinate quantities of air, has proved, that, as John Rey the phyſician had before obſerved, ſo much air is abſorbed during calcination, that the calcined metal acquires preciſely that quantity of weight which the air loſes during this proceſs; and that the portion of air abſorbed actually remains in the metallic calx, as the calces of mercury may be reduced merely by expelling that fluid. Other facts led him ſtill farther. He obſerved, with Prieſtley, that the air which remains after the proceſs of calcination or combuſtion, can no longer ſerve to promote new proceſſes of the ſame kind; that it extinguiſhes flame, ſuffocates animals, and, in a word, has acquired a different nature. He likewiſe found that its diminution is exactly proportioned to the quantity abſorbed by the combuſtible body. On the other hand, air extracted from metallic calces has been found to be three or four times purer than atmoſpheric air. It not only promotes combuſtion, but even renders it much more rapid. A given quantity of the former will ſerve for the inflammation and total combuſtion of three or four times that quantity of matter which may be conſumed by the help of the ſame portion of the latter. To this ſingular fluid obtained from the calces of mercury, Dr Prieſtley, who firſt diſcovered it, gave the name of *dephlogiſticated air;* becauſe he conſidered it as atmoſpheric air deprived of the phlogiſton, which, according to him, is diffuſed through the whole atmoſphere. Its phlogiſton he believed to be retained by the mercurial calces, which are gradually reduced as this elaſtic fluid is diſengaged by heat. But as that name may lead to a falſe idea of its nature, we ſhall give it the name of *vital air;* for it alone is the great agent in reſpiration, as well as combuſtion; and to uſe the expreſſion of M. Lavoiſier, it has four times as much of the genuine nature of air as common air has.

From thus obſerving, that air is abſolutely neceſſary to combuſtion, and that part of the air neceſſary to the calcination of metals remains in the calces, M. Lavoiſier was at firſt led to think, that combuſtion conſiſted in the abſorption of pure air by the combuſtible body. Abſtracting the water and vapours contained in atmoſpheric air, he conſidered the ſubſtance that remained as a compound of two very different elaſtic fluids. One of theſe, which is the only genuine air, and which promotes combuſtion by precipitating itſelf into the combuſtible body, and uniting with it, is vital air. It generally compoſes a fourth part of the atmoſphere, and ſometimes even a third part, when it is in its pureſt ſtate. The other fluid is deleterious to animals, and extinguiſhes flame; and it conſtitutes three-fourths or two-thirds of the atmoſphere: it was at firſt named mephitic air. When a combuſtible body is expoſed to the air and kindled, a portion of the vital air in the atmoſphere becomes fixed in that body, and its combuſtion continues till it abſorb all the vital air immediately around it. The reſidue of the air, after it has loſt this pure vital part, can no longer contribute to combuſtion. It regains this power on being again qualified with a due quantity of pure air extracted from nitre or a metallic calx. This elegant theory propoſed by M. Lavoiſier in the years 1776 and 1777, appeared to explain all the phenomena of combuſtion. It accounted for the additional weight acquired by metallic calces, and the extinction of flame by air that had been already employed in combuſtion. But M. Lavoiſier, after continuing his experiments upon the ſubject, has thought proper to modify and enlarge it by new obſervations. The bright flame which is obſerved on immerſing a burning body in vital air, or on pouring this fluid on the ſurface of a flaming ſubſtance (which may be done by means of an ingenious machine of his invention) made him deſirous of knowing whence it proceeded, and whether, according to the theory of Stahl, it were owing to the diſengagement of phlogiſton.

ton. He inquired into this with the more attention becauſe the celebrated Macquer had ſtill perſiſted, notwithſtanding *his* diſcoveries, in maintaining Stahl's theory, but had laboured to reconcile *his* theory with that of the father of philoſophical chemiſtry. Macquer was of opinion, that pure air became fixed in combuſtible bodies in conſequence of their phlogiſton being diſengaged; and that pure air and phlogiſton were reciprocally precipitated; the one from the atmoſphere into the combuſtible body, the other from that body into the atmoſphere: in every proceſs of combuſtion pure air extricated phlogiſtion into a ſtate of liberty, and aſſumed its place; and in the reduction of metals, phlogiſton diſengaged pure air and occupied the room which it had formerly poſſeſſed. M. Lavoiſier obſerving that the bright ſparkling flame before mentioned, which affords the ſtrongeſt indication of the preſence of light or the matter of fire in a ſtate of activity, ſeems rather to ſurround the exterior part of the body in combuſtion, than to proceed as if it were diſengaged from it;—has been led to think that light and heat are ſeparated from vital air, in proportion as it is abſorbed by the body in combuſtion. His preſent opinion is, that vital air, like all other aëriform fluids, is a compound, conſiſting of a certain principle ſuſceptible of ſolidity, and of fire or the matter of heat; that to its poſſeſſing the latter it owes its ſtate of elaſtic fluidity; and that, being decompoſed in combuſtion, its fixed, ſolid principle, by entering into combination with the combuſtible body, increaſes its weight and changes its nature,—while the matter of fire that it contains is diſengaged under the form of light and heat. Thus, the modern doctrine has beſtowed on vital air what Stahl attributed to phlogiſton. If combuſtion conſiſt in the diſengagement of fire, it is the air, not the combuſtible body, which burns. As to the principle which, in combination with the matter of fire, conſtitutes pure or vital air, though M. Lavoiſier have not fully explained its nature, yet as it is often known to form acids by entering into combination with combuſtible ſubſtances, he has conferred on it the name of *oxygene* *. With this baſe, the ſulphuric, arſenic, and phoſphoric acids, &c. are produced in the combuſtion of ſulphur, arſenic, and phoſphorus, &c. In all theſe bodies it is ſtill the ſame. It is to be obſerved, that according to this new theory, the vital air which is obtained from metallic calces did not exiſt in theſe calces under that form. It becomes ſuch, in conſequence of the combination that takes place between the heat and light communicated through the veſſels in which the calces are contained during this proceſs, and the *oxygene* by which they are conſtituted calces.

Such is the preſent ſtate of chemical doctrine concerning the nature of atmoſpheric air, and its influence on combuſtion. The theory of which we have given an account, is daily gaining new ſtrength. The objections urged againſt it have but little weight: they even ſhow, that if its oppoſers were better acquainted with it, they would ceaſe to raiſe their voice againſt it, and that when

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* M. Lavoiſier gave it at firſt the name of *oxigyne*; but finding it neceſſary to apply an analogous name to ſome other ſubſtances, before known by improper denominations, we have changed the *gyne* into *gene*, as more expreſſive of its Greek derivation.—T.

it ſhall become generally known, it will be unanimouſly received by the learned.

Reſpiration is a phenomenon nearly reſembling combuſtion. Common air is decompoſed in the one as well as in the other; that it may contribute to either, it muſt contain a certain quantity of vital air. When it is deprived of all its vital air, the mephitic reſidue is fatal to animal life. Reſpiration is in fact but a ſlower combuſtion, in which part of the heat of vital air enters the blood as it paſſes through the lungs, and is by it conveyed through the whole body. In this manner animal bodies receive their ſupplies of heat, which are abſolutely neceſſary, as they are conſtantly giving out the heat which they contain, to the atmoſphere and other ſurrounding bodies. To maintain the heat of the blood is, therefore, one of the chief purpoſes of reſpiration; and this beautiful theory explains why the blood of thoſe animals that reſpire either no air or but very little, is always cold.

Meſſrs. Lavoiſier and De la Place have diſcovered another ſervice which the air performs in the act of reſpiration. It abſorbs a certain principle that exhales from the blood, and appears to be of the ſame nature with coal. That ſubſtance being reduced into vapour enters into combination with the oxigenous part of vital air, and forms the carbonic acid which is diſcharged from the lungs by expiration. This fact,—the formation of the carbonic acid in the atmoſpheric air reſpired by animals, at the ſame time when the *mephitic* air is ſeparated,—explains why ſuch dangerous effects enſue from the ſhutting up of a number of perſons together in cloſe places; ſuch as happens in theatres, hoſpitals, priſons, and the hold of a ſhip, &c. After this, we can no longer be ſurpriſed at the noxious effects of air altered by reſpiration, by which perſons of delicate conſtitutions and great ſenſibility of nerves are particularly liable to be affected.

The atmoſphere which encompaſſes our globe appears, therefore, to be ſuffering continual alterations from the two great phenomena of combuſtion and reſpiration. That fluid would be very inadequate to theſe two great purpoſes, were there not other means provided for renovating the atmoſphere, and maintaining it with conſtant ſupplies of vital air. In the following chapter, and in the third part, we ſhall ſee that the organs of vegetables are deſigned by nature to extract this vital air from water, as well as to pour it into the atmoſphere, when ſtruck by the rays of the ſun.

§ III. *Of the diſtinguiſhing Properties of that Mephitic Air, or Gas Azote, (or Nitrogene*,) which enters into the Compoſition of Atmoſpheric Air.*

From the preceding account of atmoſpheric air, it appears to be a compound body, conſiſting of two gaſes or elaſtic fluids; one of which maintains combuſtion or reſpiration, but the other is entirely unfit for either of theſe purpoſes. The firſt, which is named vital air, exiſts in the proportion of 0,27 or 0,28; while the latter amounts to 0,73 or 0,72. We have aſſerted the firſt to be a compound of the caloric and the oxigenous principles; the ſecond, like all other gaſeous bodies, is alſo a compound of the caloric principle with a baſe ſuſceptible of ſolidity. To this elaſtic fluid, which conſtitutes more than two thirds of the atmoſphere, M. Lavoiſier at firſt gave the name of *mofette*; becauſe it extinguiſhes combuſtion, and deſtroys animals. But ſince all gaſſes, except vital and atmoſpheric air, are equally noxious, and are therefore all equally intitled to the name of *mofettes* or *mephites*, which has been always applied to elaſtic fluids unfit for reſpiration;—we have adopted the words *gas azote* as the peculiar denomination of *this* aëriform fluid: and we may of conſequence apply the ſubſtantive *azote*, or the term azotic principle, to the baſe of this gas; which, like the oxigenous principle, the baſe of vital air, becomes fixed by entering into combination with a number of ſubſtances. In order to give ſome idea of the nature of this gas azote, we ſhall mention a few of its properties. It is ſomewhat lighter than common air, and therefore occupies the upper part of rooms in which the air hath been altered by combuſtion or reſpiration. Though ſo noxious to animals, in the ſtate of elaſtic fluidity, yet the azotic principle, its baſe, is one of the component principles of animal bodies; from which it is extracted in great abundance. It is likewiſe one of the conſtituent parts of volatile alkali, or ammoniac, and of the nitric acid: it appears to be abſorbed by vegetables, and perhaps alſo by animals. It is highly probable, that the ſame principle enters into the compoſition of all alkaline bodies; and may be conſidered as a genuine *alkaligenous* principle, in oppoſition to the baſe of vital air, to which we have given the name of the *oxiginous* principle. Thus we are led to conſider the atmoſphere as a vaſt reſervoir of *acidifying and alkalifying* principles, though it be itſelf neither acid nor alkaline.

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* I think *nitrogene* adopted by M. Chaptal, a more correctly analogical name for this gas than *azote*; unleſs farther diſcoveries ſhould induce us to adopt rather the term *alkaligene*, as expreſſive of a more general property belonging to it.—H.

Here we can only mention theſe properties; in the ſucceeding part of the work they ſhall be more particularly explained. Here we have only endeavoured to point out the difference between the two fluids of which our atmoſphere conſiſts, and to fix the reader's attention on the nature of each as diſtinct from the other.

CHAP.

CHAP. VII.

Of Water.

WATER was long thought to perform an important part in almoſt all the phenomena of nature, and to be capable of aſſuming a vaſt variety of forms, and entering into many combinations, without ſuffering any alteration of nature, or becoming unable to reſume its original ſtate. But the late reſearches of Meſſrs Lavoiſier, Meunier, de la Place, and Monge, have diſcovered that water, like air, is compounded of more ſimple principles which may be obtained ſeparate. The period of this important diſcovery conſtitutes a glorious æra in the hiſtory of chemiſtry. We ſhall afterwards ſee by what means theſe philoſophers accompliſhed the analyſis of water. Let us firſt conſider the phyſical properties of this body.

§ I. *Of the Phyſical Properties of Water.*

PHILOSOPHERS define water to be an inſipid, ponderous, and tranſparent fluid, without colour or elaſticity, extremely ſuſceptible of motion, and capable of paſſing through the various ſtates of aggregation, from the ſolidity of ice to the tenuity of vapour or elaſtic fluidity.

It is found in almoſt all natural bodies; but nature has united it with many ſubſtances with which art has not yet learned to make it enter into combination. It is obtained from wood, and from the moſt ſolid bones; it is known to exiſt in the hardeſt and moſt denſe calcareous ſtones; it conſtitutes the moſt conſiderable part of animal and vegetable fluids, and even enters into the compoſition of the ſolid parts of ſuch bodies. Theſe are the facts which gained it a place among the number of the elements.

The natural philoſopher views it as exiſting in maſſes over the globe, filling up its cavities, or furrowing its ſurface. Its hiſtory comprehends that of the eternal ice which covers the ſummits of ſome lofty mountains and the polar ſeas, of lakes, rivers, rivulets, ſprings, clouds, rain, hail, and ſnow. It is diſtinguiſhed into terreſtrial and atmoſpheric water. It attracts the curious inquiry of the philoſopher, in its paſſing ſucceſſively from the ſurface of the earth into the atmoſphere, and from the atmoſphere upon the riſing heads of hills; and again, in its gathering into ſtreams, producing ſprings, fountains, and rivers; and in the laſt form, holding its headlong courſe to its great reſervoir the ſea. Obſerving the phenomena of this immenſe maſs of water, we behold it agitated with the moſt tremendous motions; we ſee its fluctuations and currents ſometimes raiſing awful liquid mountains; we ſee it ſometimes encroaching on the limits of the earth, and ſometimes retiring within its ancient boundaries. Here new iſlands ſpring up from its depths; there the foundations of iſles of ancient name are ſapped, and they ſwallowed up in its bowels. If we trace its action in ſubterraneous cavities, we there find it engaged in humbler labours, producing ſalts and cryſtals, and depoſiting them in the clefts of the rocks. All theſe objects muſt come under our attention in purſuing the natural hiſtory of water. But we muſt firſt examine its phyſical and chemical properties.

The moſt remarkable of theſe is its being ſuſceptible of various forms, and becoming by turns a ſolid, a liquid, or a vaporous body. Let us conſider it under each of theſe three modifications.

I. *Of Water in the State of Ice*

Ice ſeems to be the natural ſtate of water; for, in chemiſtry at leaſt, we conſider that, as the natural ſtate of any body, in which its aggregative force is ſtrongeſt: But as it appears much more frequently in a liquid ſtate, liquidity is ſtill conſidered as the natural ſtate of water.

Several phenomena highly worthy of obſervation, occur in the formation of ice.

1. The change of a liquid into a ſolid body. which takes place on the freezing of water, occaſions a heat of ſome degrees. In a thermometer immerſed into freezing water, the mercury riſes ſome degrees above 32°; while in another, in the open atmoſphere of the ſame temperature, it either remains fixed at that point or ſinks below it. It appears, therefore, that part of the heat which is fixed in water in a liquid ſtate, is diſengaged and eſcapes into the atmoſphere when it aſſumes a ſolid form; and the ſpecific heat of ice is actually leſs than that of water. A ſimilar diſengagement of heat is obſerved in the cryſtallization of ſalts.

2. The external air promotes the formation of ice. Water in a cloſe veſſel freezes but very ſlowly; but expoſe it to the open air, even in the ſame temperature,

and ice will almoſt inſtantly appear. A ſimilar phenomenon is obſerved in the cryſtallization of ſalts: many ſaline ſolutions, which in cloſe veſſels are maintained in this ſtate, will almoſt in an inſtant diſplay cryſtals, if you open the mouth of the veſſels and expoſe them to the contact of the atmoſphere.

3. Gentle motion is favourable to the production of ice. The ſame thing is obſervable of ſaline cryſtallizations. By ſhaking ſome ſolutions, which otherwiſe would not produce cryſtals, we ſometimes ſee theſe appear while the ſhaking is continued. I have often obſerved this in ſolutions of calcareous nitrate and muriate. Theſe analogies between the formation of ice and that of ſaline cryſtals prove, that the former is actually a ſpecies of cryſtallization.

4. The bulk of a piece of ice appears to be greater than that of the water of which it is formed; bottles and other glaſs veſſels are burſt in conſequence of the freezing of liquids with which they are filled. But this effect is to be aſcribed not to the water, but to the air which is diſengaged from it during its congelation.

When ice is formed, it is diſtinguiſhed by the following properties.

1. It has been obſerved by M. Mairan, that when formed by a ſlow congellation, its cryſtals are in the form of needles croſſing each other at angles of—from 60° to 120°. Sometimes its cryſtallization takes a regular and determinate form. M. Pelletier, a diſciple of M. D'Arcet's, and member of the college of pharmacy, obſerved in a piece of fiſtulous ice, cryſtals in the form of flat quadrangular priſms, terminating in two dihedral ſummits, but with great varieties. On the other

ther hand, when ice is ſuddenly formed, and in large maſſes, it becomes one irregular ſolid, exactly like that produced when ſolutions of ſalts are preſſed cloſe together, and ſuddenly cooled *.

2. Its ſolidity is ſo great, that it may be reduced to powder, and carried about by the wind. In very cold climates, ice becomes ſo hard that it may be hewn into pieces like ſtone, and uſed in building. Nay we are even confidently told that maſſes of ice have been hollowed into cannons, and charged and diſcharged ſeveral times before melting.

3. Its elaſticity is very great, much greater than that of water in fluid ſtate. Throw a piece of ice on a ſolid plane, it rebounds from it like any other hard body.

4. It has a keen, ſharp taſte, nearly approaching to cauſticity. Every perſon knows what kind of ſenſation ice gives when applied to the ſkin. Phyſicians employ it in external applications as a tonic or diſcuſſive, &c.

2. Its gravity is leſs than that of the fluid on which it ſwims; which ſeems to be occaſioned by its containing a greater quantity of air in proportion to its bulk. The ſame phenomenon takes place on moſt of thoſe bodies that admit of concentration by cold, and fuſion by heat, ſuch as butter, fat, wax, &c. and ſtill ariſes from

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* M. Sage informs us, that a piece of ice containing within it unfrozen water; if broken ſo as to ſuffer the water to run out; exhibits in its cavity beautiful, tetrahædral priſms, terminating in four-ſided pyramids.

M. Macquart relates, that when it ſnows at Moſcow, in a humid ſtate of the atmoſphere, the air is obſerved to be loaded with cryſtallizations, regularly flattened, and thin as a leaf of paper. Theſe cryſtallizations conſiſt of fibres diverging into ſix different rays from a common centre. H.

from the ſame cauſe; for every ſubſtance is by itſelf more denſe and weighty in its ſolid than in a fluid ſtate.

6. Its tranſparency, at leaſt in irregular maſſes, is obſcured by air bubbles. You may be convinced of this by examining a piece of ice attentively; and if the cavities be opened under water, the air which they contain will be ſeen to iſſue in bubbles from its ſurface.

7. It melts at ſome degrees above 32°; the liquefaction proceeding gradually from the ſurface to the centre.

8. Paſſing from a ſolid to a liquid ſtate, it produces cold in the ſurrounding atmoſphere. Modern chemiſts think that it abſorbs heat when it melts: and that the quantity of the caloric principle which becomes fixed in it on that occaſion, is equal to the quantity of heat diſengaged when it paſſes from fluidity into the ſtate of ice. The ſame phenomenon is common to all fluid bodies that can be condenſed into ſolids, and again reduced to fluidity by the variation of their temperature

II. *Of Water in a Fluid State.*

The properties of water in a fluid ſtate are very different from thoſe of ice.

1. Its taſte is much fainter, for it is generally conſidered as inſipid. And yet people that drink much of it, can diſtinguiſh differences in its taſte at different times, &c.; which ſhows that it is not abſolutely inſipid.

2. Its elaſticity is leſs than that of ice. Some experiments of the Academy *del Cimento*, have even cauſed this property to be entirely denied to it. But the Abbé Mongez has proved the elaſticity of water by a ſeries of ingenious reſearches; and has even ſhown, that the

experiments of the Academy admit of an inference directly oppoſite to that which has been deduced from them. For the ſpheres of metal, which had been filled with water for thoſe experiments, continued to exſude liquid drops after being taken out of the preſs; which could not have happened if the water had ſuffered no compreſſion.

3. In the ſtate of a liquid aggregate, water is more under the influence of the affinity of compoſition. From this circumſtance it has obtained the name of the great ſolvent of nature. It does indeed enter into union with many bodies, and even contributes highly to the mutual combination of bodies.

4. It ſeems incapable of combination with light, which paſſes through it without producing or ſuffering any alteration. Light is known to change its courſe in paſſing through water, ſo as to aſſume a more perpendicular direction.

5. Heat dilates it to a gaſeous ſtate. Its paſſing from a liquid ſtate to that of aëriform fluidity, conſtitutes ebullition. The cauſe of this phenomenon is, that, part of the maſs of water under examination having aſſumed the form of an elaſtic fluid, the heat no longer ſuffers it to remain in union with that which is ſtill liquid: each bubble riſes from the bottom of the veſſel, and aſcends into the atmoſphere, in obedience to the action of heat. I have explained the cauſe of ebullition at large in my *Memoires de Chimie*, publiſhed in 1784, page 334.

The weight of the air has a remarkable influence on the ebullition of water. It oppoſes its dilatation and evaporation: And in proportion as the gravity of the air is leſs or more, the reſiſtance which it oppoſes to the volatilization of water muſt be weaker or more powerful. Thus, Fahrenheit obſerved, that the temperature of water in a ſtate of ebullition is not always the ſame. In order then, to know with greater certainty the preciſe degree of heat at which water boils, we muſt conſult the barometer as well as the thermometer, and we ſhall find the requiſite heat always proportioned to the weight of the air.

The influence of the weight of the air on the rarefaction and ebullition of water becomes more remarkable when we make our obſervations at various heights in the atmoſphere. Thus, *cæteris paribus*, water boils eaſier on the ſummit of a mountain than in a valley or on a plain; the heat requiſite to produce ebullition being leſs in the former ſituation than in either of the two latter. All fluids are eaſily rarefied at very elevated heights; for this reaſon, liquids that are highly volatile, ſuch as ſpirit of wine, æther, and alkaline or ammoniac gas, loſe much of their ſtrength on the tops of mountains; a fact which has been generally obſerved by natural philoſophers, and fully determined by an obſervation made by M. de Lamanon, at the height of more than 1800 toiſes above the level of the ſea. Abſtract the weight of the atmoſphere with the pneumatic engine, and you may heat water to ebullition, and reduce it to a vapour, without raiſing it to the temperature of 122°.

Laſtly, A third circumſtance, beſide the heat and the gravity of the atmoſphere, which affects the ebullition of water, is the dryneſs or humidity of the atmoſphere; but as the influence of this circumſtacce is entirely chemical, we ſhall reſerve the conſideration of it to the next ſection.

6. Boil water in a cloſe veſſel, and with a ſuitable apparatus for collecting the vapours; let theſe be condenſed by cold, and conducted into a receiver; what is thus obtained is diſtilled water. By this means water is obtained pure, and ſeparated by thoſe earthy and ſaline matters which almoſt always alter it, but are now left in the bottom of the veſſel. Chemiſts, who always need pure water for their experiments, provide themſelves with it in this way. They pour river or fountain water into a cucurbite of copper tinned over within: this they cover with a capital inſerted into a refrigeratory filled with very cold water, for the purpoſe of condenſing the vapours; which are thus cauſed to paſs in drops into glaſs-veſſels, prepared for their reception. But in order to obtain diſtilled water in the greateſt purity, an alembic peculiarly adapted for this purpoſe muſt be employed. To abridge the proceſs of diſtillation, this veſſel ſhould be prepared on particular principles; the cucurbite ſhould be broad and flat, and the capital of the ſame form. Water thus diſtilled is perfectly pure. Chemiſts formerly made uſe of ſnow or rain water; but theſe are now known to contain ſolutions of ſome extraneous ſubſtances.

Diſtilled water has an inſipid taſte, and when drunk oppreſſes the ſtomach with a kind of weight; but after being expoſed to the open air, and briſkly ſhaken, it recovers its taſte, and may be drunk with ſafety. Diſtillation does not alter water, it only deprives it of the air which is always united with it in its ordinary ſtate, and communicates to it that lively freſh taſte which renders it potable. Boerhaave diſtilled a quantity of water 500 times ſucceſſively, without being able to diſcover any alteration upon it. Some philoſophers have at different periods aſſerted, that water is changed into earth; becauſe, at each new diſtillation, it leaves a certain quantity of an earthy reſidue in the bottom of the veſſel. M. Lavoiſier has made a ſeries of the moſt accurate experiments, with a view to determine this. By weighing the glaſs veſſels employed in the proceſs of diſtillation, and doing the ſame with the water diſtilled and its reſidue, he has diſcovered that this earth is nothing but a part of the matter of the veſſels ground down by the action of the water.

III. *Of Water as an Elaſtic Fluid.*

WHEN water is reduced by the action of fire into the ſtate of vapour or elaſtic fluidity, it acquires new properties which diſtinguiſh it from what it was under the two former modifications.

1. If the air into which it is received be above the temperature of 65°, 45′, and not overcharged with humidity, it becomes perfectly inviſible.

2. If the temperature of the atmoſphere be below 54°, 30′, and, if it be already loaded with moiſture, the watery vapour forms a white or grey cloud, which is very plainly diſtinguiſhable: The reaſon of this is, that it is not diſſolved in the humid air, as will be afterwards ſhown; but a true precipitation actually takes place.

3. Its dilatation is ſo conſiderable, that, as M. Wath aſſures us from the moſt accurate computation, it occu-

pies, in this form, 800 times the ſpace which it fills when liquid.

4. Such is its elaſticity, that when compreſſed, it produces dreadful exploſions; and is happily employed in mechanics to move enormous maſſes. Its utility in that valuable machine the ſteam-engine is well known both to philoſophers and artiſans.

5. Agreeably to one of the moſt uniform laws of the affinity of compoſition, it has a greater tendency to combination in this ſtate, in which its aggregative force is weakeſt, than in the two former. Chemiſts have frequently occaſion to obſerve with what rapidity water in the ſtate of vapour diſſolves ſalts, ſoftens mucous ſubſtances, corrodes and calcines metals, &c.

6. It is entirely diſſolved in air; when precipitated from the atmoſphere, it conſtitutes dew. This ſolution obeys the ſame laws with ſaline ſolutions; as has been ſhown by M. Le Roy of Montpelier, in an excellent memoir on the elevation and ſuſpenſion of water in the atmoſphere, (*Melanges de Phyſique et de Medicine, Paris*, 1771.)

7. One of the moſt remarkable phenomena of water in a vaporous ſtate, is its power of quickening the combuſtion of oil; as in the experiment of the æolipile applied to the enameller's lamp, in common fires of mineral coal or charcoal, and in the burning of greaſe; inſtead of extinguiſhing, water rather increaſes the ſtrength and fury of the flame in all theſe inſtances. Theſe phenomena led Boerhaave to think that flame was in a great meaſure compoſed of water. We ſhall ſee how much this ingenious conjecture of Boerhaave's

haave's is confirmed, or at leaſt juſtified by the modern diſcoveries concerning water, when we come to ſhow that this fluid, in a vaporous ſtate, increaſes the violence of flame, in conſequence of being itſelf decompoſed by the bodies in combuſtion.

8. Water in vapour, and diſſolvedin the air, is condenſed, and part of it precipitated, when expoſed to a temperature a few degrees above the freezing point; it then reſumes its liquidity; and in this manner is dew produced. Sometimes, when expoſed to a ſudden cold ſeveral degrees below the freezing point, it is congealed into icicles, and ſeems to ſuffer a kind of cryſtallization: hence thoſe hoar, icy incruſtations that are formed in winter on the windows of apartments expoſed to the north: hence too thoſe ſmall icy flakes into which the aqueous vapours iſſuing from the lungs are formed in Siberia and other countries expoſed to an extreme cold.

§ II. *Of the Chemical Properties of Water.*

No other natural body is ſuſceptible of more combinations than water; and it has, on this account, long held the name of the *great ſolvent of nature*. The waters of the ſea, of lakes, of rivers, ſprings, and fountains, are far from being pure, and are impregnated with almoſt every other ſubſtance, eſpecially with ſaline matters.

It combines with air in two ways: 1. It abſorbs this elaſtic fluid and retains it without paſſing from its liquid ſtate. It even appears that water owes its pleaſant freſh taſte to the air thus combined with it. The pneumatic engine proves the reality of this combination; when the air above the water is exhauſted, that which is mixed with it, is gradually diſengaged in the form of bubbles. The air contained in water may be obtained by diſtilling the water in a pneumato-chemical apparatus. When water is boiled, the firſt bubbles that ariſe, conſiſt of air, and the water, after loſing them, has no longer the ſame lightneſs or reliſh. It recovers theſe properties by being expoſed for ſome time to the open atmoſphere, or by being briſkly ſhaken. 2. Air, with a certain degree of heat, diſſolves water, and renders it elaſtic and inviſible like itſelf. The greater its heat, the greater alſo is its power of maintaining water in a ſtate of ſolution. Le Roy of Montpelier has examined with minute attention the ſtate of water in the atmoſphere. His ingenious experiments ſhow, that the drieſt hot air, if incloſed in a flaſk, and cooled to a certain temperature, affords a precipitate of water; that more or leſs aqueous vapour is neceſſary to ſaturate the ſame quantity of air according to its heat; and that this water is precipitated from the atmoſphere through the night, and forms a particular kind of dew. He has even been led to think, from theſe facts, that the weight of the atmoſphere depends upon the quantity it contains of this water, which is always in proportion to its temperature.

Though it be not conſiſtent with the method which we propoſe to follow, to enter upon the examination of ſaline matters in this place; yet we muſt obſerve, that water, as it poſſeſſes in an high degree the property of diſſolving them, always contains a certain quantity of ſome ſaline ſubſtance. Calcareous ſalts are moſt frequently mixed with water, and communicate ſome diſagreeable, and ſometimes even noxious, qualities to well and river waters. Theſe are ſometimes alſo found to contain a portion of the carbonic acid, of clay, of iron, and of the extracts of vegetables altered by putrefaction. All ſuch waters are unwholeſome; thoſe vitiated with the former mixture are called crude, hard waters: they have an inſipid taſte, are heavy upon the ſtomach, and unfavourable to digeſtion; and being likewiſe often purgative, the uſe of them is not without danger. It is, therefore, an object of conſiderable importance to diſtinguiſh the quality of water; to diſcover whether it be impregnated with any bodies which may communicate to it noxious properties; and to adopt means for purifying it from ſuch a mixture.

Good wholeſome water is generally diſtinguiſhed by the following characteriſtics. It is very clear and limpid; no extraneous body alters its tranſparency; it has no ſmell; it has a lively, freſh, and almoſt pungent taſte; it boils readily, and without loſing its tranſparency; it entirely diſſolves ſoap, in ſuch a manner as to produce a homogeneous fluid, without clouds or lumps; it boils leguminous vegetables without hardening them: if tried by an addition of thoſe liquors that are named *re-agents*, ſuch as alkalis, and ſolutions of mercury and ſilver with nitre, it loſes neither its purity nor tranſparency; or at leaſt if it ſuffers any change of this kind, it is almoſt imperceptible. Laſtly, it paſſes eaſily through the ſtomach and the inteſtines, and is favourable to digeſtion. Spring or river water, which filtrates or flows through ſand, is in continual motion and is not polluted with the putrefaction of animal or vegetable ſubſtances,—is found to poſſeſs all theſe properties: but filth muſt not be conveyed into it by ſewers; the channel muſt not be filled up ſo as to divert or ſlacken its courſe; nor muſt hemp be ſteeped, or foul linens waſhed in it, &c. On the contrary, water which ſtagnates in ſubterraneous cavities, which iſſues from a calcareous or gypſeous ſoil, which has no current, which is overgrown with plants or crawls with inſects, which is very ſhallow, with a ſoft muddy bottom, conſiſting of putrid vegetables; all ſuch water exhibits quite different qualities. Its taſte is inſipid or even nauſeous; it has the ſmell of a mouldy or putrid ſubſtance; it is often green or yellowiſh; green or brown flakes of matter, the remains of putrefied vegetable ſubſtances, are ſeen ſwimming in it; it turns vegetable blues to green; it becomes dark and muddy when boiled; forms clouds with ſoap, and hardens all kinds of pulſe; the re-agents cauſe it to give precipitates in greater or leſs abundance; it oppreſſes the ſtomach, remains long upon it, and retards digeſtion.

Several means are uſed to correct theſe bad qualities, which have been adopted entirely from the conſideration of its phyſical and chemical properties.

1. Stagnant waters are put in motion by cutting out for them a ſloping channel, expoſing them to the action of mills, cauſing them to riſe in ſpouts through the air, or to tumble down in caſcades. By theſe means the putrid gas and ſpiritus rector are made to evaporate, extraneous matters are collected and depoſited in the bottom, and a conſiderable quantity of air is attracted into combination with the water.

2.

2. Marſhes and pools are cleanſed of all putrefying animal and vegetable ſubſtances: and this cannot be done without agitating their waters at the ſame time, which is alſo ſerviceable.

3. Water is filtrated through jars or fountains, the bottoms of which are covered with fine ſand and ſponges: theſe need to be renewed from time to time. The bottoms of ſmall rivulets naturally covered with a bed of mud, are alſo laid with ſand and pebbles.

4. The above are means for purifying water by ſeparating from it ſuch heterogeneous matter as may happen to float in it; but they cannot deprive it of any ſaline ſubſtances that exiſt in it in a ſtate of ſolution. To ſeparate theſe from water, it muſt be boiled, left to ſettle and cool till it become clear, then filtrated through paper or pure ſand, and expoſed to the air in broad ſtone veſſels. After undergoing this proceſs, it may be drunk with ſafety. Ebullition frees hard water of the principle which occaſions its diſagreeable ſmell, and cauſes it to precipitate part of its calcareous ſalts: but to produce the laſt effect, the water muſt be boiled for half an hour, or for ſo long time as may be neceſſary to make it diſſolve ſoap, and to deprive it of the property of hardening pulſe.

5. If boiling be found inſufficient for purifying water of its calcareous ſalts, as ſometimes happens when it is ſtrongly impregnated; theſe muſt then be precipitated by boiling it with a ſmall quantity of potaſhes, or for want of potaſhes with common aſhes; the ſalts then fall to the bottom; and the water being ſuffered to ſettle, and expoſed to the air, acquires all the qualities which we wiſh it to poſſeſs.

6.

6. We may alſo make uſe of ſome ſubſtances to correct the diſagreeable and noxious qualities of water, ſuch as ſugar, meal, barley, corn, honey, pot-herbs, and ſome labiated aromatic plants. But theſe cannot, like the former means, communicate to it the qualities of pure water; they only ſubſtitute one taſte in the place of another.

This account of the chemical properties of water repreſents it only as a powerful agent in combination, capable of entering into union with many natural bodies. But in many of its combinations it ſuffers a remarkable alteration, which was not taken notice of till the month of April 1784; and which is highly worthy of the attention of chemiſts.

Water has long been known to favour combuſtion in ſome inſtances, as in the enameller's lamp, in the inflammation of oils, in ſtrong conflagrations, &c. Some philoſophers had thought themſelves authorized by theſe facts to conclude, that water was ſometimes changed into air: but we are indebted to a few French academicians for a more accurate account of theſe phenomena, and of the nature of water. M. Lavoiſier having obſerved, with M. De la Place, that when inflammable gas is burnt in a cloſe veſſel, by the help of vital air, a product of pure water is obtained (a fact which was obſerved almoſt at the ſame time by M. Monge, with the moſt accurate attention, in the laboratory of the ſchool of Meziere), concluded, that this product muſt be compoſed by the combination of vital air with inflammable gas; and that theſe were the conſtituent principles of water. This theory, by which M. Lavoiſier preſumed to deprive water all at once of the character of a ſimple elementary body, which it had ſo long maintained, met with keen oppoſition; and its author found himſelf under a neceſſity of eſtabliſhing it by analytical as well as by ſynthetic facts. He therefore attempted to decompoſe this fluid, by exhibiting to it bodies, the affinity of which with one of its principles was ſo ſtrong, that they might be expected to ſeparate it from the other. Obtaining the aſſiſtance of M. Meuſnier, in his reſearches on this head, thoſe two philoſophers read, in the academy, on the 21ſt of April 1784, a Memoir, proving that water is not a ſimple ſubſtance, but a genuine compound of the baſe of inflammable gas with that of vital air or the oxigenous principle; and that the two principles may be eaſily ſeparated from each other. To obtain theſe two matters ſeparate, M. Lavoiſier at firſt employed the following proceſs. In a ſmall bell-glaſs, above ſo much mercury, he put a certain quantity of very pure diſtilled water mixed with iron filings: Theſe filings were gradually calcined; an inflammable elaſtic fluid was diſengaged, and collected immediately above the mercury; and in proportion as theſe two phenomena appeared, the quantity of the water was diminiſhed. By proſecuting this experiment farther, the iron may be entirely calcined and totally decompoſed; for the water, in M. Lavoiſier's opinion, both occaſions the calcination of the iron and gives out the inflammable gas. As the fluid is compoſed of the oxigenous principle and the baſe of inflammable gas, the iron gradually depriving it of the former, combines with that principle to form a metallic oxide, and leaves the inflammable gas diſengaged. Such was the firſt experiment in which this enlightened chemiſt accompliſhed the decompoſition of water. But in thoſe reſearches which he proſecuted in conjunction with M. Meuſnier, he followed a much ſhorter and more concluſive proceſs. Placing the barrel of a gun in a furnace, and heating it red-hot, he dropped a certain quantity of water through it. In this proceſs, the water being reduced to vapour is decompoſed as ſoon as it comes into contact with the red iron, and the oxigene which it contains becomes fixed in the metal; as appears from the increaſe of its weight and the alteration of its ſubſtance. The baſe of inflammable gas being ſet at liberty, paſſes quickly through the gun-barrel, and is received into bell-glaſſes placed for that purpoſe at the oppoſite end. On a repetition of their experiments, with all the preciſion poſſible, thoſe philoſophers diſcovered, that water contains about ſix parts of the oxigenous principle with one of the baſe of inflammable gas; that of conſequence this laſt principle conſtitutes but a ſeventh part of the compound; that it is thirteen times lighter than common air; and that it occupies, when at liberty, fifteen hundred times the ſpace which it filled in its aqueous combination.

Water appears to act in the ſame manner on many other combuſtible bodies, which it reduces with more or leſs facility to a burnt ſtate, and to afford uniformly a quantity of inflammable gas. It may be decompoſed with zinc, charcoal, or oils; with the laſt of theſe, by dropping the water into boiling oil in a retort, the neck of which is immerſed under the glaſſes of a common pneumato-chemical machine. But great caution is neceſſary to prevent the exploſion that takes place when the water riſes in the vacuum produced in the neck of the retort by the ebullition of the oil. To determine certainly whether a combuſtible body, ſuch as a metal, a coal, &c. be capable of decompoſing water, immerſe a piece of it red hot into a veſſel of water, under a bell-glaſs filled with the ſame fluid, and the inflammable gas, which is always diſengaged whenever water is decompoſed, will be received into the glaſs. Theſe, namely, the decompoſition of water, and the production of inflammable gas, are the reaſons why bubbles ariſe when red iron is plunged into water, as has been obſerved by Meſſrs Haſſenfraſt, Stouttz, and D'Hellancourt, of the royal mineralogical ſchool of France. A ſimilar diſengagement of inflammable gas, the conſequence of the decompoſition of water, takes place when a piece of flaming charcoal is thrown into a quantity of this fluid.

Theſe are the newly diſcovered facts concerning the nature and compoſition of water. Meſſrs Lavoiſier and Meuſnier think, therefore, that this fluid is a compound of about ſix parts of the oxigenous principle and one of the baſe of inflammable gas, or, more accurately, of 0.86 of the former body, and 0.14 of the latter; that iron, charcoal, and oils, having a ſtronger affinity with the oxigenous principle than it has with the baſe of inflammable gas, enter into combination with it, leave the combuſtible elaſtic fluid diſengaged, and thus decompoſe water; that this liquid may be again formed by burning inflammable gas with vital air; that when this proceſs of combuſtion is carefully performed, a quantity of water is obtained, which anſwers preciſely in weight to the quantity of the two gaſes, by the combination of which it was produced; that in many chemical operations, water is produced by this combination; and that, therefore, if ſpirit of wine and oils be burnt under a chimney, proper for condenſing their vapours, and fitted to the worm-pipe of a ſtill, the other end of which is joined to a receiver, a quantity of water will be obtained almoſt always greater than that of the combuſtible liquid which affords it; becauſe the inflammable gas, diſengaged from the liquid, combines with the pure part of the atmoſpheric air which is decompoſed during the combuſtion.

These diſcoveries, and the theory founded upon them, cannot but form one of the moſt illuſtrious æras in the hiſtory of natural philoſophy. As it is of the utmoſt importance to conſider all the conſequences of which it admits, with all poſſible care, we ſhall here add a few obſervations, in order to convey more diſtinct and accurate ideas of it.

We have mentioned, that all aëriform fluids owe their gaſeous ſtate to the matter of fire or heat combined with them. Inflammable gas depends on the ſame principle: For as the decompoſition of water and its change into inflammable gas always require an high temperature, and as the more violent the heat applied, the more rapid is the change; this gas, therefore, appears to acquire its amazing levity, and to aſſume the aëriform ſtate, in conſequence of a conſiderable quantity of heat being abſorbed by its aqueous baſe; which is the reaſon why it can never be obtained but in a ſtate of extreme fuſion. It becomes, therefore, neceſſary to beſtow a particular name on this baſe of inflammable gas, which when combined with the oxigenous principle, the baſe of vital air, is ſuſceptible of a ſolid form, as in the inſtance of ice. This baſe being conſidered as one of the eſſential principles of water, muſt be diſtinguiſhed by a name expreſſive of that property. We have adopted the word *hydrogene*, or *hydrogenous* principle, as anſwering the purpoſe. And we call water a compound of the oxigenous principle, or the baſe of vital air, and the hydrogenous principle, or the baſe of inflammable gas. And as there are many inflammable elaſtic fluids, ſuch as alcohol, æther, volatile oils, &c. when reduced to elaſtic fluidity; we diſtinguiſh this principle of water in its aëriform ſtate by the name of *hydrogenous gas.*

In a future chapter we ſhall have occaſion to review this important ſubject; in this place it is ſufficient to have ſhown, that water is not a ſimple; but a decompoſable body. Nature in her grand operations effects the ſeparation of principles with much greater facility than art, and by many more ways than art can ever diſcover or adopt. It is in conſequence of its decompoſition that water purifies the atmoſphere, by pouring into it ſtreams of vital air; that it contributes to the formation of ſaline matters, of the principles of which pure air is always one; and that ſuch a quantity of inflammable gas is often diſengaged from ſtagnant waters, as ſometimes to overload the atmoſphere, and to produce igneous meteors, in conſequence of being kindled by the electric fluid in its ſtruggles to maintain its equilibrium. Laſtly, This fine diſcovery of the component principles of water, its decompoſition and recompoſition, illuſtrates and explains many of the phenomena of nature, particularly the renovation of the atmoſphere, the ſolution of metals, vegetation, fermentation, and putrefaction; as ſhall be ſhown more at large in ſeveral ſucceeding chapters of this work.

C H A P. VIII.

Of Earth in general.

THE philoſophers of antiquity believed in the exiſtence of a ſimple ſubſtance, the principle of hardneſs, gravity, dryneſs, and fixity, and the baſe of all ſolid bodies, to which they gave the name of *earth*. This opinion, founded ſolely on abſtract reaſoning and hypotheſis, has long been taught in the ſchools, and is ſtill maintained by a number of philoſophers. Paracelſus gave the name of earth to all reſidues obtained by analyſis. But ſucceeding chemiſts following the advice of Glauber, to examine reſidues with as much attention as products, were ſoon convinced, that thoſe were far from being pure earth; and the opinion of Paracelſus was of conſequence exploded. Boerhaave having adopted the notion of Paracelſus under ſome reſtrictions, obſerved, that after every analyſis, there remained a dry, inſipid, heavy, colourleſs matter; poſſeſſing in ſhort all the properties of earth. But theſe matters, when chemically examined, are found to differ ſo conſiderably from one another, that they cannot, with any propriety, be comprehended under one general denomination.

Beccher, as has been already mentioned in our account of Principles, admitted three different kinds of earth; vitrifiable, inflammable, and mercurial. Stahl conſidered the firſt of theſe as the only genuine earth; and

Macquer follows Stahl in thinking vitrifiable earth the pureſt and the moſt elementary.

In order to determine what judgement we ought to form on this matter, let us firſt examine attentively the properties which chemiſts agree in aſcribing to elementary earth. We find ſix which have been conſidered as its diſtinguiſhing characteriſtics; namely, gravity, hardneſs, inſipidity, fixity, infuſibility, and inalterability. But all of theſe properties are found as well in the earth which forms the baſe of rock-cryſtal, quartz, and vitrifiable ſtones in general, as in clays. If then a number of ſubſtances, conſiderably different from one another in many reſpects, be found to poſſeſs in common all the diſtinctive properties attributed to elementary earth, are we to conſider them as ſo many ſimple primary earths? Or, ſhall we rather adopt the opinion of Stahl and Macquer, who, finding vitrifiable earth to poſſeſs in a more eminent degree all the properties of elementary earth, conſider it as the only genuine primary earth, and the others merely as bodies formed by it in combination with different principles?

However plauſible this opinion, however reſpectable its authors, we cannot agree to conſider vitrifiable earth as the only primary and elementary earth: 1. Becauſe this earth is not found in equal purity, even in all the ſtones in which Stahl and Macquer have themſelves admitted its exiſtence; for inſtance, let quartz, rock-cryſtal, and flints, be examined and compared. 2. Becauſe all the diſcriminating properties of earth are found to belong to many ſubſtances which differ from vitrifiable earths only in poſſeſſing thoſe characteriſtics in a leſs eminent degree. 3. Becauſe vitrifiable earth has not been hitherto ſhown to be, as ſome chemiſts think it, the baſe of all ſolid matters, and of all the various kinds of earth.

We muſt adopt the following ſentiments with regard to this matter. We obſerve many ſubſtances in nature poſſeſſing the properties of earths; among which it is impoſſible to diſtinguiſh which is the moſt ſimple, as chemiſts find them all to poſſeſs nearly the ſame degree of ſimplicity: Beſides, though one of theſe ſhould be demonſtrated to be more ſimple than the reſt, it would be farther neceſſary to ſhow that it enters into their compoſition, and conſtitutes the principle of their coherence and ſolidity. Wherefore, without preſuming to determine what is properly elementary earth, we ought to admit the exiſtence of various kinds of earths, and to ſtudy their properties, in order that we may recogniſe and diſtinguiſh them whenever chemical analyſis offers any of them to our attention, combined or ſeparate.

Chemiſts have long allowed the exiſtence of ſeveral kinds of earthy matters: but the earlier claſſifications of theſe matters are faulty, becauſe the properties aſſumed as characteriſtics were neither ſufficiently numerous nor ſuch as the ſubſtances were certainly known to poſſeſs. Such, for inſtance, is the diviſion of earths into mineral, vegetable, and animal: for though the fixed reſidues obtained by a laſt analyſis of organized matters, after lixiviating their aſhes, be generally deſtitute of taſte or ſmell, dry and indiſſoluble, yet theſe properties are not ſufficient to entitle them to a place among the earths, as they poſſeſs neither inalterability, infuſibility, nor ſimplicity. That ſubſtance which compoſes the dry, ſolid baſe of animal bones, and which, from its dryneſs, inſipidity, and inſolubility, had obtained the name of earth, has been, within theſe few years, diſcovered to be a true ſaline matter; as we ſhall ſhow at large in the chemical hiſtory of the animal kingdom. And we may with great probability conjecture, that the inſipid, inſoluble parts, which remain after the laſt analyſis of other animal matters, are of the ſame nature. The name metallic earths, given to the calces of metals from their dryneſs, and becauſe ſome of them are deſtitute of ſmell and incapable of ſolution, does not properly belong to them; for they are extremely fuſible, and are, every one of them, compounds, as ſhall be afterwards ſhown.

The mineralogiſts who have treated of the hiſtory of earths, have formed a more regular and accurate arrangement of them than chemiſts, who have conſidered this ſubject only in general, ſo far as it is connected with the theory of chemiſtry. Moſt of the modern philoſophers who have attempted a claſſification of theſe matters, have characterized them by their chemical properties, and have by that means thrown much new light on the natural hiſtory of the mineral kingdom. Wallerius, Cronſtedt, and Monnet, have given complete ſyſtems of mineralogy on this plan. No chemiſt has made more numerous experiments on earths and ſtones than Pott, who has given a methodical arrangement of thoſe bodies according to his own obſervations. The continual labours of M. D'Arcet, and the many analyſes of ſtones made by Bergman and Bayen, likewiſe merit the higheſt praiſe. We ſhall not attempt to exhibit and compare the ſeveral claſſifications of theſe philoſophers: our preſent object is not to detail the natural hiſtory of earthy matters, but merely to give the reſults of the various reſearches which have been directed to this purpoſe, with a view to ſhow how many kinds there are of earth conſidered chemically, and what are the characteriſtic properties of each kind.

Before proceeding farther, we muſt obſerve, that in our opinion no diſtinction ſhould be made between earths and ſtones as to claſſification; becauſe, when we conſider them chemically, their ſubſtance is the ſame, and only their aggregation different. Grit-ſtone, for inſtance, is but ſand agglomerated by the force of aggregation; and ſand is nothing but grit-ſtone, the integrant parts of which are divided, and their aggregation broken: the ſame chemical properties are common to both.

Pott has divided earths and ſtones into four claſſes; the vitrifiable, the argillaceous, the calcareous, and the gypſeous. From later diſcoveries it appears, that the ſubſtances hitherto known by the name of calcareous earths, are true neutral ſalts: gypſeous ſtones have been likewiſe diſcovered to be a kind of ſaline ſubſtance. Only two, therefore, of Pott's four claſſes of ſtones actually belong to this diviſion of natural bodies. Dr Black, whoſe name will long mark one of the moſt illuſtrious æras in the annals of modern chemiſtry, by examining the baſe of Epſom ſalt, has diſcovered it to conſiſt of a peculiar ſubſtance, to which he has given the name of magneſia, and claſſed it among the earths. And his opinion has been unanimouſly adopted by chemiſts. Bergman, in analyſing ponderous ſpar, has diſcovered a peculiar earth, to which he has given the name of *terra ponderoſa*, and which we call *barytes*.

We think theſe two laſt ſubſtances ought to be diſtinguiſhed from earths properly ſo called, for reaſons to be mentioned in the following chapters.

Thus we acknowledge as true earths none but ſuch matters as are abſolutely inſipid, inſoluble and infuſible; and we diſtinguiſh, by a chemical examination, what ſubſtances poſſeſs theſe properties. We admit only two kinds of pure earth, equally ſimple and equally elementary.

The firſt is that which conſtitutes the baſe of rock-cryſtal, quartz, grit-ſtone, flints, and of almoſt all hard ſcintillating ſtones. Its chemical character is to ſuffer no alteration even from the moſt violent action of fire, but to retain its hardneſs, tranſparency, and all its other properties, to whatever degree of heat it be expoſed. It has been called *vitrifiable earth*, becauſe it is the only ſpecies of earth capable of forming, in combination with alkalies, tranſparent glaſs. But the name which we prefer is *ſilice*, derived from that of ſiliceous earth, which has been likewiſe given it becauſe it is conſtantly found in ſilices.

The ſecond kind of earth which we conſider as ſimple and pure, is pure argillaceous or *aluminous* earth. The following properties conſiderably different from thoſe of the former ſpecies, form its peculiar character. However pure, it is almoſt always opaque; or if it enter into any tranſparent ſtones, theſe are much inferior in tranſparency to ſiliceous ſtones. It is always diſpoſed in thin layers or laminæ, one above another. This diſpoſition correſponds to the cryſtalline form which the former ſpecies conſtantly affects. Though it have no ſtronger taſte than ſiliceous earth, yet it appears to act in ſome manner on our organs; for it adheres to the tongue: which property naturaliſts expreſs by ſaying, that *it ſticks to the tongue.* Its force of aggregation is never ſo ſtrong as that of the former earth; for which reaſon argillaceous ſtones are never very hard, but may be broken by a blow with a hammer, without being cut or ſtruck till they gave fire, like ſcintillating ſtones. The aggregative force of aluminous earth being ſo weak, renders it much more ſuſceptible of combination than the other kinds; and accordingly clays are much ſeldomer found pure than either quartz or rock-cryſtal. From this it may be eaſily inferred, why clays are almoſt always coloured, and why few of them poſſeſs all the properties of the aluminous character in any eminent degree. Aluminous earth ſuffers an alteration from the action of heat, to which ſiliceous earth is not liable. Inſtead of remaining, like the latter, unchanged when expoſed to an ardent heat, it acquires an addition of aggregative force. It even aſſumes, in ſuch circumſtances, ſome of the properties of the ſiliceous earth; its hardneſs and averſion to combination. Water acts on aluminous earth, penetrates into its ſubſtance, adheres to it, and renders it ſoft and ductile. The exiſtence of this combination appears from the difficulty with which the adheſion between theſe two ſubſtances is overcome, a ſtrong and long continued heat being neceſſary to effect a ſeparation between them. The properties which this ſpecies of earth poſſeſs of compoſing a paſte with water, and becoming hard by the action of fire, render it a very valuable material in the arts. Laſtly, another property of aluminous earth, which diſtinguiſhes it from the ſiliceous ſtill more than any of the former, is its capacity of entering into combination with a vaſt number of other bodies. So ſubject is aluminous earth to the affinity of compoſition, that we find it a principle in many compounds; and for this reaſon we have enumerated and deſcribed its properties more at large, in order that it may be readily recogniſed when obtained in analyſes.

Theſe are the two kinds of earthy matter which appear worthy of being conſidered as diſtinct claſſes, and likewiſe as elementary ſubſtances, ſince they have not hitherto been decompoſed. We are not ſufficiently acquainted with their origin, their formation and their chemical properties, to pronounce as ſome chemiſts have ventured to do, that one of them is ſimpler than the other, and that the other is nothing but a modification of it. We cannot think ourſelves as yet authoriſed to advance, that the earth of rock-cryſtal, or ſiliceous earth, is the baſe of the aluminous, to conſtitute which it only needs to be attenuated, divided, and wrought up in a particular manner; becauſe no chemiſt has hitherto accompliſhed ſuch a tranſmutation.

The two earthy matters, of the properties of which we have here taken a general view, are ſeldom found pure. Rock-cryſtal is the only body wich affords ſiliceous earth in this ſtate; doubtleſs becauſe it is exceſſively hard, and poſſeſſes the force of aggregation in an high degree. Even there, it is often coloured by the addition of ſome extraneous ſubſtance. In quartz it is ſtill oftener altered by combination with ſome colouring matters. But aluminous earth is ſtill ſeldomer found pure. In ſhort, almoſt all the earths and ſtones which naturaliſts have diſtinguiſhed by different names, are compounds of one or two ſimple earths, or of ſaline earthy ſubſtances, particularly of chalk and magneſia, and ſometimes of metallic matters, of which iron occurs the moſt frequently. To be convinced of this, the reader needs only to caſt his eyes on M. Monnet's work, in which he has arranged ſtones according to their conſtituent parts. That chemiſt's plan of arrangement certainly merits no ſmall praiſe; but while it exhibits to view all the advantages which lithology can derive from chemiſtry, it at the ſame time ſhows how far we are from an accurate and certain claſſification of ſtones according to their chemical properties. This ſubject falls under our diſcuſſion in the following chapters.

PART SECOND.

The MINERAL KINGDOM: MINERALOGY.

SECTION I.

EARTHS *and* STONES.

CHAP. I.

General View of Mineralogy: General Diviſion of Minerals, and particular Diviſion of Earths and Stones; their various Characteriſtics.

ALL the bodies of the globe which we inhabit are the objects of natural hiſtory. So grand and ſublime is this ſcience, when conſidered with a view to its general ſcope! ſo extenſive, when traced through all the minute details into which it enters! Its obſervation ranges from the meteorous phenomena of the atmoſphere to the changes which the matters depoſited in the ſtrata of our earth undergo. All the bodies ſcattered over its ſurface, ſeas, lakes, rivers, brooks, mountains, hills, valleys, plains, and caverns, engage the attention of him who cultivates natural hiſtory. The inanimate matter of the globe, and the animals inhabiting it, are equally the ſubjects of his curious inquiry. The eye of genius may indeed comprehend the whole under one grand and extenſive view: but humble ſcrupulous obſervation confines itſelf to minute detail; detaches the ſeveral parts of this great whole; examines them apart from one another; and thus divides the ſcience into a number of ſeparate branches. Many a man of invincible perſeverance, has ſpent his life in obſerving and deſcribing the manners and operations of inſects; and yet the ſubject is not exhauſted.

The ſtudent might therefore be deterred from the ſtudy of natural hiſtory as too arduous and diſguſting a taſk; but thoſe who have ſucceſsfully proſecuted the ſcience, have endeavoured to ſmooth the difficulties of the road to its attainment, by adopting means for rendering it eaſier of comprehenſion, and for aſſiſting the memory. Theſe are called *methods.* They conſiſt in arrangements of natural bodies, according to their properties. The characteriſtics on which ſuch a claſſification is founded ought to be ſtriking and invariable.

One of the moſt diſtinct and important is a diviſion of all natural bodies into three great orders, which are named *kingdoms*; the mineral, the vegetable, and the animal. Though the two laſt of theſe ſeem to poſſeſs ſome leading properties in common, yet the difference between them in point of form and exterior organization is ſufficient to make us conſider them as ſeparate orders.

Minerals compoſe the ſolid maſs of the globe, or at leaſt its exterior cruſt through which the efforts of men have penetrated. Their bulk and dimenſions are increaſed only by the juxta-poſition of their parts and by their attractive force. They are liable to no change or variation, but ſuch as are occaſioned by the mutual chemical action of bodies. And for theſe reaſons they are named *rude, inorganized, inanimate bodies.*

Vegetables, again, increaſe by the operation of an interior power: they have organs to refine and convert into nouriſhment, the juices which they derive from the earth and the atmoſphere. They ſpring up, live, and die; by a real generation, they propagate other bodies like themſelves.

Laſtly, Animals have organs more complex than thoſe of vegetables; undergo more rapid changes; and are, from their ſuperior ſenſibility and loco-motive powers, much more ſubject to the influence of ſurrounding bodies.

The branch of natural hiſtory which comprehends the deſcription of minerals, is named *mineralogy.* The firſt naturaliſts who attempted claſſification, arranged minerals into a great many claſſes. They admitted into their arrangements, as ſo many diſtinct orders of minerals, water, earth, ſand, ſoft ſtones, hard ſtones, precious ſtones, figured ſtones, ſalts, ſulphur, pyrites, minerals properly ſo called, and metals, &c. Concerning the progreſs that mineralogy has made ſince the days of Henckel, one of the firſt who wrote in a methodical manner on this department of natural hiſtory, till the appearance of M. Daubenton, whoſe claſſification is a maſter-piece of accuracy and preciſion, the reader may conſult the ſyſtems publiſhed during that period; of which a collection has been made by M. Mongez junior.

nior *. He traces the ſucceſſive improvements which the ſcience has received from the labours of Bromel, Cramer, Henckel, Wolterſdorff, Gellert, Cartheuſer, Juſti, Lehman, Wallerius, Linnæus, Vogel, Scopoli, Romé de Lille, Cronſtedt, De Borne, Monnet, Bergman, Sage; concluding with thoſe of M. Daubenton, who has accompliſhed all that could be wiſhed.

To make ourſelves acquainted with minerals, the firſt thing to be done is, to diſtinguiſh them into ſo many claſſes marked, each by ſome leading and diſtinct properties. We ſhall accordingly divide them into three. Under the firſt, we ſhall arrange thoſe ſtones and earths which are inſipid, inſoluble, and incombuſtible: under the ſecond, ſaline matters, having a ſtronger or fainter taſte, ſoluble in water, but incombuſtible: and, under the third, combuſtible ſubſtances inſoluble in water, and affording either a weaker or ſtronger flame when expoſed to the contact of fire, and at the ſame time not excluded from the acceſs of air.

Moſt of that part of the maſs of our globe with which we are acquainted conſiſts of earths and ſtones, which by their inſipidity, inſolubility, and incombuſtibility, are diſtinguiſhed from ſalts and inflammable bodies. Being regularly arranged in ſtrata or layers; they form mountains, hills, and plains; in mountains, they are diſpoſed either in huge ſhapeleſs maſſes, or in inclined horizontal layers; in plains, they are ranged in horizontal ſtrata, and covered with a bed of vegetative earth, produced by the accumulation of the remains of organized bodies. Often, however, ſuch large maſſes appear under a regular cryſtalline form in ſubterraneous cavities or

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* Manuel du Mineralogiſte.—Paris, 1784.—F.

or clefts. Moſt of them appear to have been formed by the action of water; and it is continually dividing, attenuating, and tranſporting them from one place to another, and cauſing them to undergo many other changes. The natural hiſtory of theſe bodies conſtitutes *geology* and *lithology*; the firſt treating of earths, the ſecond of ſtones: But the two ſhould be united under one claſs; for all earths, excepting mould formed of the reſidues of putrefied organized ſubſtances, are nothing but ſtones, the aggregation of which is deſtroyed; and ſtones again are formed by the union of earthy matters.

As there are a vaſt number of different kinds of earths and ſtones, and a knowledge of them is highly important in ſcience, as well as of great uſe in the arts of life; philoſophers have ſought to diſtinguiſh them from one another, and to give certain directions for recognizing them wherever they occur. Ancient naturaliſts did not think of dividing them into diſtinct claſſes by their peculiar properties; they were content with deſcribing their general qualities, and followed the order of their real utility or fancied value. Few of the ſtones, therefore, mentioned by Pliny in his natural hiſtory, can now be found. Modern naturaliſts, obſerving the inconveniencies which attend this way of deſcribing ſtones, have adopted a different method, in order to eſtabliſh more obvious and laſting diſtinctions. By obſerving their exterior and ſenſible properties, they have arranged them into orders, genera, and ſpecies; and have thus rendered the ſtudy more eaſy and advantageous.

Form, hardneſs, interior ſtructure, colour, and the appearance they exhibit when broken, are the properties tics which have been aſſumed as characteriſtics of earths and ſtones. To theſe ſome naturaliſts have added ſome of their chemical properties, eſpecially the manner in which they are affected by fire, and the alterations which they ſuffer from acids. Let us here examine each of theſe properties, in order to underſtand the application of the general principles of lithology to the particular hiſtory of each of the genera of ſtones.

§ I. *Form conſidered as a Characteriſtic of Stones.*

By the form of Stones, we underſtand the order and relative arrangement of their ſurfaces. The eye, at the very firſt glance on a collection of ſtones in a cabinet, perceives ſome of them to be of a regular geometrical figure, and others irregular maſſes; and obſerves, that regularity of form is in ſome inſtances accompanied with tranſparency, in ſome with opacity. Uniform obſervation has eſtabliſhed it as a certain fact, that ſome ſpecies of ſtones always follow a particular mode of cryſtallization; while others never appear but in irregular fragments. Several naturaliſts are of opinion, that all ſtony matters poſſeſs the property of aſſuming a cryſtalline form; that ſome indeed poſſeſs it in an higher degree, and diſplay it more invariably than others, but that all have ſome peculiar cryſtalline form, which appears in their minuteſt particles. Such is the opinion of M. Romé de Liſle, who has given a very copious and accurate hiſtory of the various cryſtallizations of mineral ſubſtances *. That philoſopher arranges the forms in which ſtones and all other mineral bodies ap-

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* Voyez ſa Criſtallographie, 2d edit. Paris 1783.

pear, under the three denominations of determinate, indeterminate, and confuſed cryſtallization; and ſhows that there is no mineral ſubſtance but appears in one or other of theſe ſtates. But the truth is, ſo many of them affect the ſecond mode of cryſtallization, and the third which is irregular and difficult to be diſtinguiſhed, that we cannot gain a ſufficient knowledge of the cryſtalline form of ſtones, to authorize us to aſſume this as one of their determinate characteriſtics. Yet a number of mineralogiſts have formed general ſyſtems of lithology and mineralogy on the principle of the regularity of the form of ſtones and minerals. Linnæus was the firſt that adopted this plan of claſſification; and though he has not entirely accompliſhed what he propoſed in introducing it, he at leaſt directed the attention of ſucceeding naturaliſts to this property of ſtones, and opened the way that has led to all the diſcoveries which have ſince been made on this ſubject.

Such is the ſtate of the preſent opinions concerning the connection between cryſtallography and the ſtudy of ſtones and minerals. It explains the formation, and ſometimes the nature of theſe ſubſtances; and often helps us to recognize and diſtinguiſh them from one another: but it is not adequate to form the baſis of a complete ſyſtem of mineralogy; it is only one of the means to be employed in a claſſification of minerals. That eminent philoſopher M. Romé de Lille, to whoſe labours we are indebted for ſo much of our knowledge concerning the peculiar forms of minerals, has not founded his diviſions of theſe bodies on their cryſtallization alone; inſtead of making this form the great principle of his claſſification, he has only examined and deſcribed the forms of mineral ſubſtances, claſſed according as their nature is ſaline, ſtony, or metallic, and according to the various combinations into which they enter.

§ II. *Hardneſs conſidered as a Characteriſtic of Stones.*

There are a great many varieties of the aggregation of the component particles of ſtones, of which lithologiſts have happily availed themſelves to diſtinguiſh them from one another. Some have ſuch ſtrength of aggregation, and ſuch a degree of hardneſs, that they yield not even to the beſt tempered ſteel, ſuch as gems or precious ſtones. Others yield, and may be cut with inſtruments, but not without difficulty, ſuch as quartz, flints, hard grit-ſtone, porphyry, and granite. All of theſe ſtones when ſtruck ſmartly againſt a ſteel blade produce a great many ſparks; which property has gained them the name of *ſcintillating* or *igneſcent ſtones.* Thoſe ſparks are minute pieces broken off from the ſteel by its colliſion with the ſtones, and kindled by the heat which that colliſion produces: that heat is even ſo intenſe, that the particles ſtruck off from the ſteel are melted; and if they be collected on a piece of white paper, and viewed through a magnifier, they will appear a parcel of half-calcined, half-vitrified ſcoriæ, like the droſs of forges. As the ſtones which act in this manner on ſteel are not all of the ſame denſity, but vary from the hardneſs of gems and rock-cryſtal to the ſoftneſs of ſand-ſtones and vitrifiable breccias recently formed, they muſt afford a greater or a ſmaller quantity of ſparks, according to their reſpective grees of hardneſs.

There are a great many other ſtones, the aggregative force of which is much leſs conſiderable, and which are ſo ſoft that they may be eaſily cut with ſteel inſtruments. Some of them, ſuch as marble and alabaſter, are ſuſceptible of a fine uniform poliſh. The reſt, and among theſe almoſt all argillaceous ſtones, admit only of an imperfect poliſh, and always retain a dull, greaſy appearance. We can at any time judge of the hardneſs of thoſe which poſſeſs this property in ſo moderate a degree, and of the poliſh of which they are ſuſceptible, by wetting their ſurface. This ſimple proceſs communicates to them a momentary poliſh, which diſappears in proportion as the moiſture evaporates.

It is to be obſerved, that many other ſtones beſide the claſs of igneſcents produce a real ſcintillation when ſtruck againſt ſteel; the reaſon of which is, that ſuch ſtones are mixtures, containing ſome igneſcent parts. Thus, ſome kinds of marble, and many calcareous breccias, ſcintillate when ſtruck againſt ſteel; becauſe they contain quartzoſe or flinty particles, intermixed with the calcareous matter of which they are moſtly compoſed.

The gravity of ſtones is neceſſarily proportioned to their denſity. Some naturaliſts have conſidered this property as of great importance in a claſſification of ſtony matters. M. de Buffon conſiders ſpecific gravity as one of the beſt means to enable us to diſtinguiſh their particular character. But ſuch nice and accurate experiments are neceſſary to determine the relative gravities of ſtones, that this property cannot very well be aſſumed as the baſis of a lithologic method; as plainneſs and ſimplicity are highly requiſite in the elements of this branch of natural hiſtory.

§ III. *Of the Fracture, Conſidered as a Characteriſtic of Stones.*

ALL ſtones when broken diſplay a certain arrangement of their integrant parts, an interior contexture and diſpoſition of their particles: but this, ſo far from being uniformly the ſame, is infinitely diverſified through the various claſſes of ſtony ſubſtances. To this appearance which ſtones preſent when broken, lithologiſts have given the name of *fracture.* By obſerving it, we may learn ſome particulars which will be of uſe to help us to diſtinguiſh their peculiar characters. From a compariſon of ſuch obſervations as have been made on the interior ſtructure of ſtones, it appears that the ſeveral ſorts of fracture which they afford may be reduced under certain heads. Some, like glaſs, give ſmooth poliſhed ſurfaces of a curved figure. This is denominated the *vitreous fracture;* it appears very diſtinctly in rock-cryſtal, quartz, &c.

Others again diſplay ſurfaces, which are uniformly ſmooth, but in their figure alternately convex and concave. The pieces may be neatly re-united. This is called the *conchoidal fracture.* The correſponding convexity and concavity are of various forms and ſizes, wide, narrow, round, oblong, deep, ſhallow, &c.; as in ſeveral kinds of flint, jaſper, agate, and petroſilex.

There is another kind of ſtones, which when broken exhibit on their new ſurfaces an aſſemblage of round projecting points, ſimilar to grains of ſand worn by water: this is called the *granulated fracture*, and is very obſervable in ſand-ſtone. The ſize and other varieties of the granulation conſtitute a number of diſtinctions among the ſtones of this ſpecies, ſerving to diverſify their characters. It is of this ſpecies we ſpeak when we ſay *fine* or *coarſe grained* ſtones.

Laſtly, There are many ſtones, the fracture of which ſhows them to conſiſt of ſmooth equal laminæ, diſpoſed one over another. Moſt of theſe are ſtones which bear the name of *ſpars;* and this is therefore denominated *the ſparry fracture.* Theſe laminæ differ from one another in extent, magnitude, thickneſs, tranſparency, and poſition with regard to the axis of the cryſtallized ſtone; for all the brilliant ſtones of this fracture exhibit a real cryſtallization. Such as are dark and without luſtre are only ſaid to be *lamellated*, not ſparry. The diſpoſition of the laminæ, ſo much diverſified in gems, and calcareous, vitreous, and ponderous ſpars, is what occaſions the brilliancy of talc, and the ſeveral kinds of feldt-ſpar, ſuch as cat's eye, the avanturine, the labradore ſtone, &c.

Some writers on this ſubject have arranged ſtones according to their fracture, conſidered in conjunction with their general form. In the year 1755, Cartheuſer publiſhed a ſyſtem of mineralogy, in which he diſtinguiſhes ſtones into lamellated, fibrous, ſolid, and granulated. But fracture alone is inſufficient for the principle of a claſſification of ſtones; it muſt be taken together with the other charcteriſtics which are examined in this chapter *.

§ IV.

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* See *L'Introduction à la Sciagraphie de Bergman, par M. Mongez le Jeune*, page 21.—F.

§ IV. *Colour conſidered as a Characteriſtic of Stones.*

THAT diverſity of colours which we obſerve in ſtones, is occaſioned by the various combuſtible or metallic ſubſtances which enter into their compoſition. Sometimes the whole ſtone is of the ſame colour, and ſometimes variegated. The colouring part of ſtones is generally an accidental property of their nature; the preſence of which is not abſolutely neceſſary, and which is liable to great varieties. There are indeed ſome kinds of ſtones which are pretty uniformly coloured, ſuch as cryſtallized gems, ſchorls, and tourmalines; and in theſe the colour may be aſſumed as a characteriſtic. But as there are other ſpecies, and more eſpecially varieties, of which it cannot be conſidered as a diſtinguiſhing property, lithologiſts therefore do not refer to it as a principle of claſſification.

Where colour may be conſidered as a characteriſtic property, we muſt diſtinguiſh between ſuch ſtones as are all of one colour, and uniformly opaque, or uniformly tranſparent, and ſuch as are variegated with ſpecks or veins; we muſt likewiſe take notice of the number of the colours which appear in any maſs of ſtone; as in marble, for inſtance, there are ſometimes no fewer than ſix or ſeven. According to the number and the diſpoſition of the colours in thoſe bodies, they are diſtinguiſhed into ſtones of one, two, three, or four colours, variegated, ſpotted, veined, punctuated, clouded, flowered, figured, herboriſed, &c.

§ V. *Alteration produced by Fire, conſidered as a Characteriſtic of Stones.*

SEVERAL mineralogiſts, not content with obſerving the exterior and more obſervable qualities of ſtones, have extended their inquiries to their chemical properties, with a view to aſſume theſe as grounds of diſtinction. The particular alteration which any ſtone ſuffers from the action of fire, is conſidered by many lithologiſts as an excellent mean for enabling us to aſcertain its peculiar nature. They have obſerved, that fire deprives ſome ſtones, ſuch as quartz, of their tranſparency and hardneſs, without changing their nature or altering their eſſential properties: others again, ſuch as rock-cryſtal, have been found to loſe not even their denſity and tranſparency when expoſed to the action of heat: and others have been found fuſible and tranſmutable into glaſs of various colours; of which kind are ſchorls, zeolites, aſbeſtos, amianthus, and granites: laſtly, there are ſtill many others, ſuch as calcareous ſtones, which fire deprives of part of their weight, deſtroying their conſiſtency, and rendering them ſoluble in water, without melting them. Other experiments, managed with more careful attention, have ſhown, that ſome ſtones loſe their colour by fire, and that to ſome it communicates a deeper ſhade. Such in general is the reſult of the experiments of Meſſrs Pott, D'Arcet, and many other chemiſts.

To complete the natural hiſtory of ſtones, it is neceſſary to take notice of theſe alterations, and to mark their differences. It appears in general, that ſimple ſtones are liable to the leaſt alteration of their properties by fire: and that in proportion as a ſtone is more or leſs compound, it is more or leſs ſubject to ſuch an alteration. But ſtill the obſervation of theſe alterations cannot be of much benefit to lithologiſts, as the experiments neceſſary to diſcover them are tedious and difficult; whereas the properties aſſumed as characteriſtics in a claſſification of ſtones, ſhould be ſuch as are obvious to the eye, or at leaſt may be diſcovered by a ſimple expeditious proceſs.

Sometimes, indeed, when we cannot determine the nature of a ſtone by obſerving its external properties, we may have recourſe to the alteration which it ſuffers from the action of fire, by means of the blow-pipe, an ingenious contrivance of Bergman's. Yet notwithſtanding the ingenious ſimplicity of this invention, the neceſſary apparatus is ſo incommodious, that it can ſcarce be rendered portable, ſo as to be uſed in a lithologic excurſion, but muſt remain confined to the laboratory *.

§ VI. *The Action of Acids conſidered as a Characteriſtic of Stones.*

Acids are the ſolvents ofteneſt uſed in chemiſtry.

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* See Bergman on the blow-pipe, at the end of his Chemical Eſſays, tranſlated into Engliſh by Dr E. Cullen. London 1784.

All the apparatus neceſſary is a blow-pipe, a piece of charcoal, a ſmall ſilver ſpoon, and three ſmall phials containing ſoda, fuſible ſalt, and borax; and the proceſs may be performed in any place where a candle can be ſheltered from the wind. Complete apparatus for the purpoſe, in a box no larger than a book in twelves, are ſold at a Mr Brown's, bookſeller, near the Strand, London.—H.

Though we have not yet treated of theſe ſalts, yet we muſt here ſay a few words of the phenomena which ſtones exhibit when brought into contact with them. The greater part ſuffer no alteration from acid ſalts; but ſome diſplay a very obſervable motion, and an agitation ſomewhat like a ſlight ebullition, if a drop of the nitric acid be cauſed to fall through a glaſs-tube on their ſurface. This phenomena bears the name of *efferveſcence*. It is owing to an aëriform ſubſtance, which being diſengaged from the ſtone by the action of the acid, riſes through the acid in a number of ſmall bubbles. That elaſtic fluid is itſelf a peculiar acid, diſengaged by the more active acid poured on the ſtone, and is the product of an actual decompoſition. All calcareous ſtones exhibit this efferveſcence when brought into contact with acids:- the nitric acid produces the moſt powerful effects, and is moſt commonly employed on ſuch occaſions. The diſengagement of an aëriform acid is a proof that the matter from which it iſſues is a ſaline combination: But as this combination is inſoluble, and without any diſcernible taſte, and as it compoſes moſt of the exterior layers of the globe of the earth, naturaliſts always conſider it as a ſtony ſubſtance.

Stones may therefore be divided into efferveſcent and non-efferveſcent. And a ſmall phial full of nitric acid becomes of conſequence a neceſſary article in excurſions to examine and collect ſtones. This, together with the magnifier and the ſteel, are all the inſtruments which the lithologiſt needs to carry with him on ſuch an expedition.

Since Bergman recommended the examination of ſtones by fire with the blow-pipe, they are alſo aſſayed with ſoda, borax, and fuſible ſalt, which act variouſly upon them according to the differences of their nature, but generally produce fuſion in ſome degree, together with other phenomena. We ſhall explain this method of analyſing ſtones more particularly in the chapter in which we treat of all the methods of effecting that analyſis.

CHAP. II.

The Lithologic Method of M. Daubenton, extracted from his Tableau de Mineralogie.

NONE of all the mineralogiſts who have attempted a methodical arrangement of ſtones, has given a more accurate or perſpicuous claſſification than M. Daubenton. The ingenuity with which this naturaliſt, ſo deſervedly celebrated, has contraſted the characteriſtics of thoſe ſubſtances, renders his method more accurate and uſeful than any before propoſed. The properties which he has aſſumed as characteriſtics are all invariable and obvious. They are chiefly regularity or irregularity of form; the various degrees of tranſparency and opacity; conſiſtency or hardneſs; the poliſh of which ſtones are ſuſceptible; the form or reſpective arrangement of the integrant parts, which occaſions the vitreous, conchoidal, granulated, lamellated, and ſpathoſe fractures; colours, in thoſe inſtances in which they are not accidental; a duſky, brilliant, or mildly lucid ſurface. As it would be impoſſible to improve upon the perſpicuity and accuracy of M. Daubenton's ſyſtem, all that we ſhall here do, is, to lay before our readers his diviſion of earths and ſtones, as he has exhibited it in his *Tableau Methodique de Mineraux*[*].

FIRST

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[*] *Tableau Methodique des Mineraux, ſuivant leurs differentes natures, et avec des characteres diſtinctifs, apparens ou faciles à reconnoitre; par M. Daubenton, &c. Paris, chez Demonvile, Pierres, Debure, Didot l'ainé, &c. in-8. de 36 pages.*

FIRST ORDER OF MINERALS.

SANDS, EARTHS, AND STONES *.

Theſe Subſtances melt not in Water like Salts, burn not like Combuſtible Bodies, nor diſplay the luſtre of Metallic Matters.

CLASS FIRST.

Stones which give Fire with Steel.

Genus I. Quartz.

Cryſtalline Subſtance, Fracture vitreous, not lamellated.

Species I. Opaque, or ſemi-tranſparent Quartz.

Varieties.
1. greaſy.
2. grained.
3. lacteous.
4. foliated.
5. cryſtallized.

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* Here we give only part of M. Daubenton's table; but in the hiſtory of ſalts and combuſtible bodies, his diviſion of theſe matters ſhall be introduced. As we follow that table ſo faithfully as to copy even the

Species II. Tranſparent Quartz, ROCK CRYSTAL,

Two pyramids of ſix ſides, with or without a ſix-ſided priſm between them.

Varieties.
1. cryſtallized.
2. rough.
3. white.
4. red. *BOHEMIAN RUBY.*
5. yellow. *OCCIDENTAL TOPAZ.*
6. ruddy, or blackiſh. *SMOAKY TOPAZ.*
7. green
8. blue. *WATER SAPPHIRE.*
9. violet. *AMETHYST.*
10. irideſcent.

Species III.

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the characters in which the ſeveral parts of it are printed, we ſhall here ſubjoin the beginning of the Author's prefatory account of it.

"Since the year 1779, this table has been exhibited in manuſcript, in the Hall of the Royal College, during the courſe of my lectures, and many copies of it have been taken. I have made repeated alterations, according as I received from others, or acquired by my own obſervation, new information reſpecting mineralogy. I have even given up for a time my deſign of exhibiting on my table the reſults of a chemical analyſis of the different minerals it contains as I had begun to do, becauſe there have not yet been a ſufficient number analyſed. My chief object in drawing out this table was to facilitate the ſtudy of mineralogy. The beſt means for diffuſing the knowledge of the ſciences is to ſimplify their elements: Methodical arrangements contribute to this end. For though it be impoſſible to include all the properties of natural bodies, in any claſſification of them, yet ſuch a claſſification is uſeful, convenient, nay even neceſſary.

Species III. Quartz in agglutinated fragments, Grit-ſtone, or Siliceous Grit,

granulated fracture.

Varieties.
1. hard grit-ſtone
2. friable
3. Levant grit-ſtone. *Very fine grain.*
4. filtering ſtone. *Porous*
5. glittering
6. veined
7. diſplaying figures of plants
8. coarſe grained.

Species IV. Quartz in ſeparate grains, SAND,

vitreous ſurface.

Varieties.
1. angular
2. round
3. moving
4. fluid.

Species

“ ceſſary. In the firſt volume of my Lectures on Natural Hiſtory, now in the preſs, I ſhall give a particular explanation of my table, in which both the advantages and defects of my arrangement of minerals will be pointed out. Here I ſhall only obſerve, that minerals are in this table diſtributed into orders, claſſes, ſpecies, and varieties. The diſtinctive characteriſtics of each article are printed in Italic characters.

“ The names in Roman capitals are thoſe which I think moſt ſuitable to the things which they are uſed to denote: Thoſe in Italic capitals are ſynonyma; the uſe of which is attended with inconveniencies, and which are inſerted only that the knowledge of the matters which they denote may be the eaſier acquired.—F.

Species V. Quartz in concrete Maſſes.

Sandy and quartzoſe Breccias, or Pudding Stones.

Genus II. Semi-tranſparent ſtones,

vitreous fracture, ſometimes conchoidal.

Species I. Agates,

of all colours, except milk white, fine red, orange, and green.

Varieties.

1. clouded
2. punctuated
3. ſpotted
4. veined
5. onyx
6. iriſed
7. preſenting the figures of herbs
8. exhibiting the appearance of moſs.

Species II. Chalcedonies,

lacteous tranſparency.

Varieties.

1. reddiſh
2. bluiſh
3. veined
4. onyx
5. irideſcent. OPALS
6. round and ſolid. GIRASOLS
7. round and hollow. ENHEDRALS
8. in ſtalactites
9. in ſediment
10. hydrophanes.

Species III. Carnelians,

beautiful red.

Varieties.
- 1. pale
- 2. punctuated
- 3. onyx
- 4. exhibiting figures of herbs
- 5. in ſtalactites.

Species IV. Sardonyx,

orange colour.

Varieties.
- 1. pale
- 2. veined
- 3. onyx
- 4. preſenting figures of herbs
- 5. blackiſh.

Species V. Flints.

gray, white, reddiſh, blackiſh.

Varieties.
- 1. with tubercles
- 2. in layers.

Species VI. The Praſeum,

green.

Varieties.
- 1. green
- 2. clouded
- 3. ſpotted.

Species VII. Jade.

greaſy poliſh.

Varieties.
- 1. whitiſh
- 2. olive coloured
- 3. green.

Species VIII. Petroſilex,

tranſparency of wax, concboidal fracture.

Varieties.
- 1. white
- 2. reddiſh
- 3. veined.

Genus III. Opaque Stones,

vitreous fracture, ſometimes concboidal or duſky,

Species I. Miln Stone,

more or leſs porous.

Varieties.
- 1. porous
- 2. denſe, or full.

Species II. Pebbles,

concentric layers,

Varieties.
- 1. ſpotted
- 2. veined
- 3. onyx
- 4. oculiform
- 5. exhibiting figures of herbs
- 6. concreted into breccias. PUDDING STONES.

Species III. Jaſper,

vitreous fracture, often duſky, without concentric layers.

Varieties.
- 1. green
- 2. red
- 3. yellow

4. brown

Varieties.

4. brown
5. violet
6. black
7. grey
8. white
9. clouded
10. ſpotted
11. veined
12. onyx
13. flowered
14. univerſal
15. fragments united in breccias.

Genus IV. Scintillating Spar. FELD-SPATH.

Species I. Feld-Spath, regularly cryſtallized.

Varieties.

1. in oblique (angled) priſms, of four ſides
2. in ſix-ſided priſms, with ſummits of two planes
3. in ten-ſided priſms, with ſummits of four facets.

Species II. Feld-Spath in confuſed cryſtals.

Varieties.

1. white
2. pearl-grey. FISH'S EYE
3. red
4. red, with brilliant ſpangles. NATURAL AVANTURINE
5. green
6. blue
7. violet
8. with green and blue ſtripes. *LABRADORE STONE*
9. with ſtripes of various colours. CAT'S EYE.

Genus V. Cryſtal Gems,

tranſparent and lamellated, not electrifiable by heat alone without friction.

Species I. Red,

Varieties.
1. Garnets
cryſtallized with 12 facets. There are alſo yellow, and brown, &c. garnets
2. The balaſs-ruby,
roſe-colour, octahedral cryſtals.

Species II. Red and orange,

Varieties.
3. Spinell ruby,
fire-coloured, cryſtallized like the balaſs-ruby
4. Vermilion,
cryſtallized like the garnet
5. Hyacinthe-la-belle,
cryſtallized under 4 hexagonal ſides with ſummits, having 4 rhomboidal facets.

Species III. Orange-coloured,

Variety.
6. Hyacinths,
cryſtallized like the hyacinthe-la-belle

Species IV. Yellow,

Varieties.
7. Oriental topaz,
cryſtallized in 2 pyramids of 6 facets
8. Saxon topaz,
cryſtallized in priſms of 8 ſides, with ſummits of 13 facets.

Species V. Yellow and green.

Variety. 9. Peridots, *CHRYSOLITES.*
cryſtallized in priſms of 6 ſides, with pyramids of 6 faces.

Species VI. Green.

Variety. 10. Peruvian emerald,
cryſtallized in 6 ſided priſms.

Species VII. Green and blue.

Variety. 11. Aqua-marina,
cryſtallized like the Saxon topaz.

Species VIII. Blue.

Variety. 12. Oriental ſapphire,
cryſtallized like the oriental topaz.

Species IX. Indigo.

Variety. 13. Indigo ſapphire,
cryſtallized like the oriental topaz and ſaphire.

Species X. Red and violet *.

Varieties.
- 14. Syrian garnet,
cryſtallized like the garnet
- 15. Oriental ruby,
cryſtallized like the oriental topaz and ſapphire.

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* Gems formed without colouring matter are white. *Note by M. Daubenton.*

Genus VI. Tourmalins, Cryſtal Gems,

compoſed of laminæ perpendicular to the axis of the cryſtal, and electrifiable by heat alone without friction.

Varieties.
1. Braſilian ruby,
red, in four-ſided priſms, with pyramids of four facets
2. Braſilian topaz.
yellow, cryſtallized like the Brazilian ruby.

Genus VII. Tourmalins,

electrifiable by heat alone without friction, laminæ not perpendicular to the axis of the cryſtal.

Varieties.
1. Tourmalins of Ceylon,
tranſparent, orange-coloured, very little channelled on the ſurface
2. Spaniſh tourmalins,
tranſparent in a ſtrong light, orange-coloured, very much channeled
3. Tourmalins of Tyrol,
fiſſures traverſing the priſm
4. Tourmalins of Madagaſcar,
SHORLS OF MADAGASCAR,
opaque, black
5. Lenticular tourmalins
6. Peridots of Ceylon,
yellow and green, very much channelled
7. Peridots of Braſil,
yellow and green, very much channelled

8. Bra-

Varieties.

- 8. Braſilian emerald, *green*
- 9. Braſilian ſapphire, *blue* *.

Genus VIII. Schorls,

not electrifiable by heat without friction, opaque cryſtals, or long green ſemi-tranſparent needles.

Species I. Cryſtallized Schorls,

Varieties.

- 1. in oblique priſms, with four ſides
- 2. in ſix-ſided priſms PIERRE DE CROIX.
- 3. in ſix-ſided priſms, with ſummits of 2 facets, or pyramids of 3 or 4 facets
- 4. in priſms of 8 ſides, with ſummits of 2 facets.

Species II. In articulated fragments.

Varieties.

- 1. ſpathoſe ſchorl, *ſtriated with ſparry ſtripes*
- 2. in maſſes. SCHORL PASTE *brilliant points in the fracture.*

Genus IX. Azure Stone,

opaque and blue.

Varieties.

- 1. purpliſh blue
- 2. blue.

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* All theſe tourmalins, excepting the lenticular, are cryſtallized in nine-ſided priſms, with ſummits of three or ſix facets. *Note by M. Daubenton.*

CLASS SECOND.

Earths and Stones which neither give Fire with Steel, nor effervеſce with Acids.

Genus I. Clays.

when moiſt they are ductile; when dry they are poliſhed by a ſlight rubbing with the finger.

Species I. Clays abſolutely infuſible.

Varieties
- 1. uſed to make pots for the glaſs-houſe.
- 2. for tobacco pipes.

Species II. Clays partly fuſible.

Varieties.
- 1. for porcelain
- 2. for Engliſh potter
- 3. for ſtone-ware.

Species III. Clays entirely fuſible.

Varieties.
- 1. for common pottery
- 2. for delft-ware
- 3. for Dutch tiles
- 4. for tiles
- 5. for bricks.

Genus

Genus II. Schiſtus,

argillaceous and foliated fracture.

Varieties.
- 1. black ſtone
- 2. common ſchiſtus
- 3. writing ſlate
- 4. poliſhing ſtones
- 5. green ſtone
- 6. hone
- 7. fragments united in breccias.

Genus III. Talc,

poliſhed gliſtening laminæ, without ſpathoſe fracture.

Species I. Talc in large leaves.

Variety. Muſcovy talc.

Species II. In ſmall leaves.

Variety. Mica.

Genus IV. Steatites,

feel greaſy, like tallow.

Species I. Steatites in layers.

Varieties.
- 1. fine French chalk (de Briançon).
- 2. coarſe French chalk (de Briançon.

Species II. Compact Steatites.

Varieties.
- 1. ſoap rock (Pierre de lard)
- 2. Spaniſh chalk.

Species III. Lapis Ollaris.

Varieties.
- 1. Como ſtone
- 2. foliated lapis ollaris.

Genus V. Serpentines,

the poliſh and colours of marble.

Species I. Opaque Serpentines.

Varieties.
1. ſpotted
2. veined.

Species II. Semi-tranſparent Serpentines.

Varieties.
1. granulated
2. fibrous.

Genus VI. Amianthus,

filaments not calcinable, leaves or flakes lighter than water.

Species I. Amianthus with ſoft fibres.

Varieties.
1. with long fibres
2. with ſhort fibres.

Species II. Amianthus with hard (brittle) fibres.

arieties.
1. Aſbeſtos, eaſily diviſible into parts (mur)
2. Aſbeſtos, not eaſily diviſible into parts (non mur)

Species III Amianthus in flakes or leaves

arieties.
1. foſſil leather
2. foſſil cork.

Genus VII. Zeolite,

cryſtallized in divergent radii, or tranſmutable into a gelly by ſolution in acids.

Species I. Cryſtallized Zeolite.

Species II. Compact Zeolite.

Varieties.
1. white
2. blue
3. red.

Genus VIII. Fluor Spar,

fragments with triangular faces, all inclined to each other.

Species I. Fluor Spar in cryſtals.

Varieties.
1. octahædrons
2. cuneiform octahædrons
3. with 14 faces
4. cubical.

Species II. Fluor Spar in irregular Maſſes.

Genus IX. Ponderous Spar,

in rhomboidal fragments, the lateral faces perpendicular to the baſes.

Species I. Cryſtallized Ponderous Spar.

Varieties.
1. in rhomboidal plates
2. in octahædrons with acute ſummits
3. in octahædrons with obtuſe ſummits
4. in hexagonal plates with acute ſummits
5. in hexagonal plates with obtuſe ſummits
6. in tables
7. in cock's-combs (or lenticular)

Species II. Ponderous Spar cryſtallized confuſedly,

BOLOGNA STONE.

Genus X. Ponderous Stone. *TUNGSTEN,*

reſembling Fluor Spar in the form of its fragments, but much heavier; it becomes yellow in acids.

CLASS THIRD.

Earths and Stones which efferveſce with Acids *.

Genus I. Calcareous Earths.

Efferveſcence with Acids.

Species I. Compact.

Variety. Chalk.

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* Though modern chemiſts conſider theſe ſubſtances as neutral ſalts, formed by the union of chalk with the carbonic acid, we ſubjoin them here after the earthy matters, in order to give a connected view of M. Daubenton's method. Naturaliſts, who employ in their arrangements none but exterior and ſtriking characteriſtics, muſt conſider theſe ſubſtances as genuine earths: but in the hiſtory of ſaline matters, they will be viewed in a different light. F.

Species II. Spongy.

Variety. Stone-marrow.

Species III. In powder.

Variety. Foſſil Flour.

Species V. Conſiſtency of cream.

Variety. Lac lunæ.

Species V. Figured.

Variety. Congealed.

Genus II. Calcareous ſtones.

indifferent colour and poliſh.

Species I. Coarſe grained.

SPECIMEN.
Limeſtone from Arcueil.

Species II. Fine grained.

SPECIMEN.
The Thunderſtone.

Genus III. Marbles.

Granulated fracture, fine colour and poliſh.

Species I. Marbles of ſix colours.

Varieties.	White, grey, green, yellow, red, and black. SPECIMEN. Marble from Wirtemberg.

Species II. Marbles of two colours.

Varieties.	15 in number, formed by the combination of 6 colours, 2 together. SPECIMEN. white and grey. Marble of Carrara

Species III. Marbles of three colours.

Varieties.	20 in number, formed by the combination of 6 colours, 3 together. SPECIMEN. grey, yellow, and black. Lumachello.

Species V. Marbles of four colours.

Varieties.	15 in number, formed by the combination of 6 colours, 4 together. SPECIMEN. white, grey, yellow, and red. Brocatello from Spain.

Species V. Marbles of five colours.

Varieties.	6 in number, formed by the combinations of 6 colours, 5 together. SPECIMEN. white, grey, yellow, red, and black. Breccias of Old Caſtle.

Genus IV. Calcareous Spar.

Regular form, ſpathoſe fracture.

Species I. Cryſtallized calcareous ſpar.

Varieties.

1. obtuſe rhomboidal figure.
   Iceland Spar.
2. lenticular rhomboidal figure
3. lenticular rhomboidal figure 6 triangular faces
4. acute rhomboidal figure
5. with 12 pentagonal faces
6. with 3 triangular faces
7. ſix-ſided priſm
8. ſix rhomboidal ſides, with 6 faces lozenge-wiſe
9. with 12 ſcalene triangular faces
10. with 12 faces of 4 or 5 ſides, and 6 quadrilateral facets
11. with 6 hexagonal faces, and 12 facets of four ſides.

Species II. Striated calcareous ſpar.

Varieties.

1. with parallel ſtriæ
2. with divergent ſtriæ.

Genus V. Concretions.

Succeſſive coats.

Species I. Stalactite Concretions.

Varieties.

1. in columns
2. tabular
3. reſembling alabaſter.

Species II. Concretions by incruſtation

Specie III. Concretions by ſediment.

Varieties.
- 1. by horizontal ſediments
- 2. by rounded ſediments.

CLASS FOURTH.

Mixed Earth and Stones.

Mixed earths.

Genus I. Sand and Clay.

Species. Sand for founders.

Variety. Sand from Fontenai-aux-roſes.

Genus II. Sand and calcareous earth.

Genus III. Clay and calcareous earth.

Species. Marle.

Varieties.
- 1. marle, Armenian bole
- 2. marle, terra ſigillata
- 3. ſtone for taking ſpots out of cloth. (pierre a detacher)
- 4. fuller's earth
- 5. porcelain earth
- 6. pipe clay
- 7. potter's clay (terre á fajance)
- 8. white marle
- 9. foliated marle
- 10. marle for manure

Mixed

Mixed Stones,

OF TWO GENERA.

Quartz and ſcintillating ſpar	Granitin.
Quartz and ſchorl	Granitello.
Quartz and ſteatites	Quartoſe ſteatites.
Quartz and mica	Micaceous quartz.
Tranſparent quartz and mica	Micaceous cryſtal.
Quartz in grit and gem-ſtone	1. Garnet on grit-ſtone. 2. Garnet in grit-ſtone.
Quartz in grit and mica	Micaceous grit.
Quartz in grit and calcareous matter	1. cryſtallized grit, 2. grit in ſtalactites.
Quartz in ſand and opaque ſtone	ſandy and ſiliceous breccias.
Quartz in ſand and ſchiſtus	ſcintillating ſchiſtus, *HORNSTONE. TRAP.*
Quartz in ſand and zeolite.	ſcintillating zeolite.
Scintillating ſpar and ſchorl paſte	ophites.
Semi-tranſparent ſtone, with opaque ſtone	jaſperated agate, or agatized jaſper.

Schorl and mica	micaceous ſpathoſe ſchorl.
Schiſtus and mica	micaceous ſchiſtus.
Schiſtus and marble	Florence ſtone.
Serpentine and marble	1. green Egyptian marble. 2. ſea green marble. 3. green antique marble. 4. green marble of Suza. 5. green marble of Varalta.
Ponderous ſpar and calcareous matter	alkaline ponderous ſpar.

OF THREE GENERA.

Quartz in ſand, ſchiſtus and mica	rough wheat-ſtone.
Quartz, gem, and mica	garnet rock.
Quartzoſe paſte, ſcintillating ſpar in ſmall fragments, and ſchorl	porphyry.
Quartzoſe paſte, ſcintillating ſpar in large fragments and ſchorl	ſerpentine. *hard ſerpentine.*
Quartz, ſchorl, and ſteatites	tuberculous rock.
Quartz, ſcintillating ſpar, and ſchorl	granite

OF FOUR GENERA.

Quartz, ſcintillating ſpar, ſchorl, and mica	granite.

CONSISTING OF MORE OR FEWER GENERA, UNITED IN BRECCIAS } univerſal breccias.

DOUBLE BRECCIAS.

Varieties.
1. Fragments of porphyry, and paſte of porphyry.
2. Fragments of granite, and ſchorl paſte.

VOLCANIC PRODUCTS*.

Genus I. Lavas, or Matters formed by Volcanoes, volcanic Matters.

Species I. Porous Scoriæ.

Varieties.
1. in irregular maſſes.
2. in ſtriped maſſes.
3. in the form of ſtalactites.
4. in fragments. LAPILLO
5. in ſmall fragments. POUZOLANA.
6. in duſt. VOLCANIC CINDERS.

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* M. Daubenton places volcanic products at the end of minerals, without ranking them under any of the four orders of which his method conſiſts. As their hiſtory is uſually ſtudied along with that of ſtones, I have annexed them here.—F.

Species II. Baſaltes,

compact and ſcintillating, blackiſh cinereous fracture, &c. with brilliant points, without ſmall plates, like thoſe of the ſcintillating ſchiſtus.

Varieties.
1. in irregular maſſes.
2. in balls.
3. in tables.
4. in priſms of 3, 4, 5, 6, 7, 8, or 9 ſides.
5. in articulated priſms.

Species III. Glaſs.

Varieties.
1. in ſeparate fibres. GLASS GALL.
2. in agglutinated fibres PUMICE STONE.
3. in compact maſſes. VOLCANIC SCORIA. *LAPIS OBSIDIANUS.*

Genus II. Volcanized Matters; that is to ſay, matters, altered by the heat of volcanoes, *appearing to have been baked, calcined, melted, or vitrified.*

Species I. Granite.
II. Garnet
III. Hyacinth.
IV. Mica.
V. Peridot.
VI. Quartz.
VII. Schorl.
VIII. Scintillating ſpar.
IX. Calcareous Subſtances.
X. Baked Earths, Tripoli

STONES, with the nature of which we are not yet ſufficiently acquainted to reduce them under certain Claſſes.

Jargon of Ceylon.

cryſtals in rectangular priſms, with pyramids of 4 triangular faces.

The name of Jargon appears to be given to many ſtones, the particular ſtructure of which is hitherto unknown.

Macles,

in ſquare or cylindrical priſms, the tranſverſe ſection of which exhibits a blue croſs.

The macle has been conſidered as a ſchorl; but the opinion has not been proved.

White Cryſtals,

in flattened priſms with 10 ſides, with two ſummits of four faces, one of which forms a concave, the other a convex angle.

Violet or green Cryſtals.

rhomboidal, with two facets inſtead of two oppoſite angles.

Theſe white, violet, and green cryſtals, have obtained the name of Schorls, although they do not appear to be of the ſame nature with ſchorls.

CHAP. III.

Of the Claſſification of Earths and Stones according to their Chemical Properties.

THOSE chemiſts who have engaged in the the ſtudy of minerals, have endeavoured to eſtabliſh diſtinctions among them, founded on their chemical properties. And though a ſufficient number of earths and ſtones has not yet been examined, to enable us to form very accurate or complete arrangements of them on theſe principles; yet it is certainly an object of importance to the ſtudent of mineralogy to know the preſent ſtate of chemical ſcience reſpecting theſe ſubſtances, and what advantage the mineralogiſt can derive from it in arranging them.

Of all the philoſophers who, ſince Cronſtedt, have attempted to arrange earths and ſtones by their chemical properties, Bucquet, Bergman, and Kirwan, have been the moſt ſucceſsful, and have given the moſt complete ſyſtems. As each of theſe gentlemen has followed a peculiar mode of arrangement, and as each of their methods poſſeſſes ſome undeniable advantages, we ſhall here lay before our readers ſucceſſive views of the three ſyſtems, and ſhall at the ſame time point out their ſeveral defects.

§ I.

§ I. *Of the Chemical Diviſion of Earths and Stones propoſed by* BUCQUET.

BUCQUET, after many laborious reſearches with a view to this object, at length formed, a little before his death, a ſyſtem of earths and ſtones, on the compound principle of their chemical properties and their exterior characteriſtics, as obſerved by naturaliſts, which he had reſolved to follow in his future courſes of lectures. In repeated converſations with him during the lingering illneſs which ended in his death, I obtained a full account of that method; which was communicated to the public in the firſt edition of this work. I ſhall now again give it as it then appeared, only adding a few notes, to take notice of the improvements which this branch of the ſcience has received ſince the year 1779.

According to Bucquet, earths and ſtones ſhould be arranged under three diviſions: the firſt comprehending ſimple earths and ſtones; the ſecond, compound earths and ſtones; and the third, mixtures of earths and ſtone.

Simple earths and ſtones, in a ſtate of purity, are inſipid, dry, hard, inſoluble, and infuſible. Whenever any of them appear to poſſeſs theſe properties in a leſs perfect degree, more eſpecially when any of them appear ſuſceptible of fuſion, they are to be conſidered as not pure, but alloyed by the mixture of ſome extraneous matter. Such as are pure, admit not of decompoſition by chemical analyſis; but the number of pure ſtones is much more ſcanty than Bucquet thought it.

Compounds earths and ſtones are to be regarded as combinations of the ſimple earths with ſaline or metallic ſubſtances. Theſe combinations have been effected by the operation of fire or water in the great laboratory of nature. Their chemical characteriſtics are, to melt eaſily, to ſuffer vitrification from the action of fire, and to be ſeparable into ſeveral ſimple ſubſtances by the action of ſolvents, more eſpecially by the action of acids.

Mixed earths and ſtones are eaſily diſtinguiſhed by inſpection. They ſeem to be formed by the irregular aggregation of ſeveral earths and ſtones, both ſimple and compound. To analyſe them, the ſeveral different matters of the irregular aggregate muſt be divided and examined each by itſelf. Their peculiar natures may be then certainly determined by chemical experiments.

DIVISION I.

Simple Earths and Stones.

These are divided into four orders.

Order I. Vitreous Stones.

These are extremely hard, and perfectly tranſparent; of a vitreous fracture; give fire with ſteel; and ſuffer no alteration in tranſparency or hardneſs from the action of heat

This firſt order contains two genera; rock-cryſtal and vitreous precious ſtones.

Genus I. *Rock-Cryſtal.*

Rock-crystal exhibits all the properties of vitreous ſtones in the moſt eminent degree. Its fracture, which is ſimilar to that of glaſs, diſtinguiſhes it from the following genus.

It may be ſubdivided into ſpecies.

1. *By the Property of Form.*

Species.

1. Inſulated hexahædral cryſtals, which two hexahædral pyramids. The Abbé Rochon has obſerved, that theſe produce a double refraction.
2. Hexahædral cryſtals, united in groups, with one or two points.
3. Tetrahædral, duodecahædral, flattened, &c. cryſtals. Thoſe of which the facets are varied and irregular are always hexahædral.
4. Rock-cryſtal in maſſes, from Madagaſcar. It produces only a ſingle refraction.

2. *By the Property of Colour.*

5. Reddiſh rock-cryſtal.
6. Smoky cryſtals.
7. Black cryſtals.
8. Yellow cryſtals.
9. Blue cryſtals.
10. Green cryſtals.

3. *By accidental Circumſtances.*

Species.

11. Hollow rock-cryſtal.

12. Containing water.
13. One cryſtal incloſed within another (emboités).
14. Rounded; pebbles from the Rhine.
15. Incruſted with metallic calces.
16. In gæodes.
17. Containing amianthus.
18. Containing ſchorl.
19. Incruſted with pyrites.

Their formation by water is proved,

1. By their tranſparency.
2. By the form of ſmall cryſtals.
3. By the incloſure of one cryſtal in another.
4. By their incloſing ſubſtances alterable by fire.

They are cut and poliſhed into vaſes and toys.

Genus II. *Vitreous Precious Stones.*

The precious ſtones which we rank under this genus, have all the properties which characteriſe rock-cryſtal, and more eſpecially its inalterability by fire. Though this may ſeem extraordinary, ſince Bergman informs us, that he found theſe ſtones to be compoſitions of ſeveral different matters; yet in their hardneſs, their tranſparency, and the manner in which they are affected by fire, they differ but little from rock-cryſtal; they are, however, inferior in hardneſs, their colour is not ſo clear and lively, and their fracture is lamellated. The differences among precious ſtones, particularly with regard to the manner in which they are affected by fire, induced Bucquet to ſeparate them, and to arrange them among thoſe of the orders of ſtones to which they have the neareſt reſemblance.

The four precious ſtones which we diſtinguiſh by the denomination of vitreous, are,

Species.

1. The oriental topaz.
2. The hyacinth.
3. The oriental ſapphire.
4. The amethyſt.

M. Daubenton has always conſidered this laſt as a quartz cryſtal.

ORDER II. QUARTZOSE STONES.

THESE are not ſo hard or tranſparent as the former; their fracture is vitreous; and they give fire with ſteel. Heat deprives them of hardneſs and tranſparency, and reduces them to a white opaque earth *. Under this order we arrange four genera.

Genus I. *Quartz.*

It poſſeſſes all the above characteriſtics.

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* It was on account of its being liable to alteration by fire, that Bucquet diſtinguiſhed quartz from rock-cryſtal, and arranged it under a particular genus. He likewiſe obſerved, that quartz dipped in water, after having been for ſeveral times ſucceſſively heated red hot, communicated to that fluid a degree of acidity. Future experiments will determine the certainty of this fact.—F.

Species.

1. Tranſparent quartz, cryſtalliſed in hexagonal pyramids; its priſms either not obſervable, or at leaſt very ſhort.
2. Tranſparent quartz in maſſes.
3. Opaque or lacteous quartz.
4. Greaſy quartz.
5. Carious quartz.
6. Green, blue, or violet quartz; priſm of amethyſt.
7. Yellow quartz, of a lamellated fracture.

Topaz $\begin{cases}\text{Saxon.}\\ \text{Braſilian.}\end{cases}$

These topazes poſſeſs all the characteriſtics of quartz.

Genus II. *Flint, Agate.*

Flints and agates are ſmall round maſſes, generally opaque, ſometimes ſemi-tranſparent, either hollow or ſolid, of various colours, and diſpoſed in ſtrata,—in chalk, as is the caſe with flints; or in clay, as agates. Their fracture is ſometimes ſcaly.

Species.

1. Grey flint.
2. Yellow flint.
3. Red flint.
4. Corneous flint; gun-flint.
5. Brown Egyptian flint.
6. Tranſparent clouded flint; German agate.
7. Red agate; male cornelian.
8. Pale red agate; female cornelian.
9. Brown or yellow agate; ſardonyx.

10. Agate

Species.

10. Agate-onyx, in concentric laminæ.
11. Agate-Cameo, in horizontal layers; but the appearance of the laminæ, and their diſpoſition with regard to the figure of the ſtone, depends in a great meaſure on the manner in which it is cut.
12. Figured agates.
    - Dendrites; herborized agates [*].
    - Anthropomorphites.
    - Zoomorphites.
    - Uranomorphites.
13. Agate, apparently mouldy; marked with ſmall green points, generally owing to moſſes.
14. Agate of four colours; elementary.
15. Grey agate; grey chalcedony.
16. White, lacteous, or chalcedony agate.
    - in layers.
    - in ſtalactites.
    - round, cacholong.
17. White agate, with a wavy reflection of the light.
    - Lapidaries agate, *chatoyant* luſtre.
    - Cat's eye.
    - Oculus mundi, or hydrophanes.
    - Opal.
    - Giraſol.
18. Brown agate, with brilliant gold-coloured points. Avanturine.
19. Oriental agate.
20. Agate containing water (Enhydre).

The formation of quartz, agates, and flints, is owing to water, as is proved,

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[*] M. Daubenton has ſhown, in a memoir read to the Academy, that herboriſed ſtones contain very fine moſſes, or ſmall grains of black iron ore.—F.

1. By their form.
2. By their layers.
3. By their moſſes.
4. By their containing water.
5. By the organized matters mixed with them, as in the moſſy or mouldy agates.

This alſo appears from the circumſtances and properties of the gæodes. Theſe are ſtone boxes, filled with cryſtals: they contain ſilex and quartz arranged in concentric layers.

Genus III. *Organic Matters converted into Silex, or Agate.*

THESE are diſtinguiſhed from the other genera of this order, by poſſeſſing the characteriſtic properties of quartzoſe ſtones under an organic form *.

Species.

1. Wood petrified, but ſtill fibrous, and ſuſceptible of poliſh.
2. Wood, the texture of which indicates its particular kind. Fir.
3. Sea-urchins and madrepores converted into ſilex.
4. Shells converted into agate.
5. Carpolites: theſe have been miſtaken for petrified

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* It would perhaps be a much more natural mode of diviſion, to arrange under a diſtinct claſs, all ſuch animal and vegetable ſubſtances as have ſuffered alteration from lying under ground. The name of that claſs might be foſſils, and it might be placed at the end of the organic kingdoms.—F.

Species.

trified fruits; they are properly ſmall *ludihelmontii* ſilicified.

6. Entrochites.

7. Lapis frumentarius ſiliceus.

This laſt ſtone gives fire with ſteel, but does not effervesce with acids. It ſeems to be formed by an aſſemblage of cornua ammonis divided perpendicularly to their volutes.

There are two opinions concerning petrifaction. Some think that organized bodies are entirely tranſmuted into ſtone: others are of opinion, that the void ſpaces formed by animal ſubſtances in ſoft earths, and the interſtices in the fibrous texture of vegetables, are gradually filled up by an accumulation of earthy matter. But we can pretend to no certain knowledge of the cauſe of this phenomenon. Vegetable matters are obſerved to become almoſt always quartzoſe, and ſcarce ever calcareous; while animal ſubſtances, on the contrary, become generally calcareous, and ſeldom quartzoſe[*]. From this fact we may almoſt conclude, that no real petrifaction takes place, and that organized bodies are not converted into ſtone: For, 1. Shell-fiſh and madrepores only loſe their mucilage or animal gluten, by putrefaction, and are reduced to calcareous ſkeletons, which exiſted during the life of the animals: 2. What is ſaid to be petrified wood, is nothing elſe than an accumulation of vitrifiable earth in moulds formed by putrefied vegetables. As the fibres of the vegetable body are gradually deſtroyed by putrefaction, a quantity of quartzoſe earth is depoſited by the water in the ſpace which they occupied: a quartzoſe ſtone is thus formed of the very figure and texture of the vegetable body, but not a particle of this ſubſtance enters into its compoſition.

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[*] Since the diſcovery of the fluoric acid gas, which poſſeſſes the property of decompoſing quartzoſe earth, ſome naturaliſts have conjectured, that petrifaction may be produced in a ſimilar manner. But this is to be regarded as mere conjecture, till ſuch time as it be ſhown that there exiſts in the interior parts of the earth an acid which maintains quartzoſe earth in a ſtate of ſolution.—F.

Genus IV. *Jaſper.*

Jasper poſſeſſes all the characteriſtics of quartzoſe ſtones. It is infuſible, but loſes its aggregation by fire: it is extremely hard, opaque, and variegated with divers colours; its facture is duſky and vitreous. It is not often found arranged in beds; it generally compoſes conſiderable maſſes or veins in rocks: It is alſo found in ſmall round lumps. Moſt ſpecimens of jaſper that we have ſeen, are mixtures of quartz and chalcedony. It ſometimes contains calcareous ſpar.

Naturaliſts have divided jaſper into a great many ſpecies. Theſe may be reduced to the following.

Species.

1. White jaſper.
2. Grey.
3. Yellow.
4. Red.
5. Brown.
6. Green.
7. Veined.
8. Spotted.
9. Green, with red points: bloody jaſper.
10. Flowered.

Jaſper is uſed for making toys, particularly cups and ſeals. There are many antique engravings on ſtones of this kind.

Genus V. *Grit, or Free-ſtone.*

Grit-stone is opaque, of a granulated fracture, much ſofter than quartz or flint; it is found in large maſſes, of various degrees of hardneſs, and ſometimes finer ſometimes coarſer grained.

Species.

1. Grit Cryſtalliſed in rhombi. M. de Laſſone has ſhown that theſe owe their form to the chalk incorporated with them *.
2. Grit in the form of cauliflowers.
3. In ſtalagmites.
4. White.
5. Grey.
6. Red.
7. Black, or Brown.
8. Veined.
9. Figured, or herboriſed.
10. Grit, of which the aggregation is deſtroyed; ſand.

Sand appears under the following varieties:

Varieties.

1. Quick-ſand.
2. Angular ſand.
3. Sand rounded by the action of water.

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* Memoirs of the Academy of Sciences for the year 1777—F.

Varieties.

4. Pure white ſand.
5. Micaceous ſand ; glarea.
6. Yellowiſh, argillaceous ; founder's ſand.
7. Ferruginous ſand ; yellow.
8. ——————— black.
9. Blue ſand ; from copper.
10. Violet ſand ; from tin.
11. Auriferous ſand.

ORDER III. ARGILLACEOUS EARTHS *and* STONES.

THESE are greaſy ; clammy, or pliant ; ſtick to the tongue ; foliated ; frequently coloured ; and diſpoſed in large maſſes, and in layers.

Their force of aggregation is leſs than that of quartzoſe ſtones ; but they have a greater tendency to combination, and are therefore often altered. Heat contracts and hardens them, ſo as to give them the appearance of quartzoſe ſtones, and to cauſe them to give fire with ſteel as well as thoſe. Water reduces them to a paſte, divides, and purifies them ; they abſorb water, and retain it with ſuch force of combination, that they cannot be again totally deprived of it.

Part of the ſubſtance of theſe ſtones combines with acids. Some chemiſts have taken clay to be nothing but ſiliceous earth altered by the ſulphuric acid ; but that opinion has not yet been fully proved.

Many naturaliſts have entertained an opinion, that vitriſiable earths, after being long expoſed to the agency of water, air, and heat, are ſeparated and reduced into fine ſoft particles, capable of combination with water, and thus paſs into the ſtate of clay. This theory being founded on ſome accurate obſervations, merits more reſpect than the former: But the evidence of neither amounts to demonſtration.

Theſe two properties of mixing with water ſo as to compoſe a ductile paſte, and again becoming hard by the action of fire, render clay fit for being wrought into tiles, bricks, pottery, delft-ware, and porcelain: and an account of theſe makes a part of the hiſtory of this kind of earths.

Naturaliſts have deſcribed a great many kinds of ſtones as belonging to this order; but they have confouded among them many falſe clays and compound ſtones; ſuch are, of the laſt, ſerpentine, zeolite, trapp, &c.

The name of *clay* properly belongs to none but ſuch earths as are hardened by fire, are diluted in water, and combine with the ſulphuric acid to form alum.

Macquer having examined a great many of them, found none abſolutely pure *. Many of them owe their colour and fuſibility to their being mixtures of various combuſtible and metallic ſubſtances.

Bucquet divided them into four genera.

Genus I. *Soft Ductile Clays.*

These, when dug from the bed or quarry, may be kneaded; but they become dry in the open air.

Species.

1. White clay; pipe clay.
2. Sandy clay.
3. Clammy blackiſh clay; for white pottery.
4. Clay, with a mixture of mica, kaolin; partly fuſible; for porcelain,

5. Me-

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* Academy of Sciences, 1758.—F.

Species.

5. Metallic clay, fuſible ; terra ſigillata ; Armenian bole
6. Pyritous clay ; fuſible ; blue, green, marble ; uſed in common pottery.

Genus II. *Dry, Friable Clays ; Clay of Tripoli.*

ALL thoſe clays which Bucquet ranked among the tripolis, are dry in the interior parts of the earth. They are all found in beds or layers, often very thin, and arranged one above another. All of them crumble down into duſt under the finger, and abſorb water readily ; they likewiſe ſtick to the tongue.

Species.

1. Dry, grey, foliated clay ; fullers earth.
2. Red tripoli. Some people take this to be a volcanic product.
3. Grey tripoli.
4. Black tripoli.
5. Rotten ſtones of an olive grey colour.

Genus III. *Schiſtus.*

SCHISTI are foliated ſtones which ſplit readily into plates : they are a mixed fuſible ſubſtance ; they are placed in huge maſſes in the bowels of the earth, and always in an oblique direction. Almoſt all quarries of ſchiſti exhibit on their exterior ſurface, and in the uppermoſt layers, impreſſions of plants of the ruſh and fern kinds, &c. of ſhells, fiſhes, or inſects, &c.

Species.

1. Black ſchiſtus, tender; ampelite.
2. Fiſſile ſchiſtus; ſlate.
3. Black, hard ſchiſtus; writing ſlate.
4. Red, brown ſchiſtus, &c.
5. Schiſtus marked with impreſſions of vegetable or animal bodies.
6. Very hard ſchiſtus, naxian ſtone, uſed for whetting razors.

Genus IV. *Feldt-Spar.*

It exiſts in the form of rhomboidal plates; its fracture is ſpathoſe, and it gives fire with ſteel: It is for this reaſon called *ſcintillating ſpar.* Though harder than ſchiſtus, it is fuſible. Bucquet ſuppoſed it to be an argillaceous ſtone, coloured by a mixture of iron. M. Monnet conſiders it as a compound of quartz, clay, magneſia, and a ſmall portion of calcareous earth. Its being but little known is the cauſe of this diverſity of opinions concerning its nature. A more accurate examination muſt determine its true character *.

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* Father Pini, an Italian naturaliſt, was the firſt who deſcribed cryſtalliſed feldt-ſpar. Since his diſcovery, it has been found in many places in France. Very regular feldt ſpar cryſtals are found at Roanne en Forez. I have given a minute deſcription of that which is found in the Alençon granites, and which is one of the moſt regular and beautiful with which I am acquainted, in my *Memoires de Chemie.*—F.

Species.

1. Priſmatic feldt-ſpar [*].
2. White feldt-ſpar [†].
3. Red feldt-ſpar.
4. Green feldt-ſpar.
5. Blue feldt-ſpar.

ORDER IV. FALSE CLAYS.

THESE reſemble clays only by having a foliated texture, and greaſy appearance; ſome of them indeed harden by fire.

They differ from clay, as not being fit for compoſing a paſte with water, and as being moſt of them fuſible in fire. They combine with the ſulphuric acid to compoſe a ſalt in the form of needles, which ſuffers no alteration from air, but is ſoluble in four or five parts of water, and does not ſwell in fire; in a word, is not alum. Bucquet, who had examined a great many of theſe ſtones, gave theſe as their characteriſtics: but as they are very little known, they may ſtill be ranked near the clays [‡].

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[*] M. Daubenton ranks this among the ſcintillating ſtones. It is diſtinguiſhed by three characteriſtics from every other ſpecies of ſtones; its texture is ſpathoſe; it yields a changing or *chatoyant* luſtre; and it gives fire with ſteel. With theſe characteriſtics, this genus muſt contain more ſpecies than Bucquet aſcribed to it. M. Daubenton included under it the fiſh's eye, the avanturine, and the labradore ſtone.—F.

[†] It has been aſcertained by experiment, that 100 parts of white feldt-ſpac, contain about 67 ſilex, 14 alumine, 11 barytes, and 8 magneſia.—H.

[‡] The Abbé Mongez, in his Introduction to Bergman's Sciagraphy, obſerves, that theſe ſtones might be with more propriety named *magneſian ſtones*. I ſhould willingly agree to uſe that name; but I believe a number of experiments are neceſſary before we can receive it as expreſſive of their nature.—F.

Genus I. *Lapides Ollares, hard.*

Their texture can ſcarce be called foliated; their appearance is greaſy; and they are ſuſceptible but of an indifferent poliſh.

Species.

1. Grey, Swediſh lapis ollaris.
2. Greeniſh lapis ollaris; Swediſh colubrine.
3. Yellowiſh lapis ollaris; Chineſe ſoap-ſtone.
4. Bright green lapis ollaris; jade. Bucquet thought the nephritic and Otaheitean ſtones to be varieties of the jade. The jade is very hard, and gives fire with ſteel. Bucquet appears to have followed Pott in placing it among the lapides ollares.
5. Dirty green lapis ollaris; colubrine.
6. Serpentine. A ſtone of a deep green, or rather blackiſh colour, with black ſpots or veins, like a ſerpent's ſkin. On account of its appearance, we have placed it at the end of the lapides ollares; it ſeems to be a compound.

Genus II. *Soft Lapides Ollares; Steatites, or Smectites.*

THESE are more of the nature of ſoap than the foregoing genus. They may be eaſily cut; they frothe with water; and ſome of them have externally a ſtriking reſemblance to ſoap.

Species.

1. White, compact ſteatites; Briançon chalk.
2. Bright Briançon chalk; the druggiſts Venice-talc.
3. White, Norwegian ſteatites.
4. Red marbled Norwegian ſteatites.
5. Reddiſh Norwegian ſteatites.
6. Green compact ſteatites from Norway.
7. Green and red ſteatites from Norway.
8. Green, foliated; ſoft colubrine of Norway.
9. Black ſteatites; uſed by ſtone-cutters.
10. Sparkling grey ſteatites; plumbago, molybdena, and very improperly black lead. Plumbago being reduced to powder, and wrought into a paſte with a mixture of iſinglaſs, is incloſed in ſmall cylinders, which are cut to a point at one end, and uſed as pencils or crayons*.

Genus

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* Since the death of Bucquet and the firſt edition of this work Meſſrs. Scheele, Gahn, and Hielm, have very ſucceſsfully inveſtigated the nature of plumbago; they have found it to be a carbure of iron. We ſhall give its hiſtory after that of ſulphur. The ſame chemiſts, more eſpecially M. Scheele, have made a very proper diſtinction between plumbago and molybdena, which former naturaliſts had always confounded together. M. Scheele conſiders molybdena as a compound of ſulphur with a certain acid, to which he gives the name of the *molybdenic* (*See the hiſtory of metals.*) It is plumbago which is uſed for pencils.—F.

In England, the plumbago uſed for pencils is not ground to powder and mixed with iſinglaſs; but cut into long ſlender pieces and incloſed in wood. Thoſe deſcribed by the author are an inferior kind.—H.

Genus III. *Talc.*

It conſiſts of poliſhed glittering plates, diſpoſed one over another, and of a gelatinous tranſparency. Theſe laminæ or plates are ſometimes cryſtalliſed in an hexagonal form, or in ſections of ſix-ſided priſms. A ſtrong fire melts it into a coloured glaſs.

Species.

1. Talc in large tranſparent plates; Muſcovy glaſs.
2. Talc in very ſmall ſilvered ſpangles.
3. Talc in very ſmall golden ſpangles. Theſe two kinds are uſed to dry writing, under the name of *gold* or *ſilver powder*.
4. Talc worn into the form of pebbles.
5. Talc in black ſpangles.
6. Talc in mixed brilliant ſpangles.

Genus IV. *Amianthus*, *Aſbeſtos*.

The ſtones of this genus conſiſt of fibres or threads diſpoſed parallel to one another, or interwoven like the texture of a web. Theſe threads are ſometimes ſtiff, ſometimes flexible; and they differ from one another in colour, length, and thickneſs. The ancients ſpun them, and made of them a kind of cloth, to which they gave the name of *incombuſtible linen*, in which they burnt the bodies of the dead, in order to preſerve their aſhes, &c.

Amianthus melts, in a ſtrong fire, into an opaque coloured glaſs.

Species.

1. Hard grey aſbeſtos, with parallel threads; ligneous aſbeſtos.
2. Hard green aſbeſtos, with parallel threads.
3. Hard green aſbeſtos; its threads in bundles.
4. Aſbeſtos, with diverging fibres.
5. Hard aſbeſtos, with ſoft fibres.
6. Hard amianthus, with parallel greeniſh fibres.
7. Hard amianthus, with parallel white fibres.
8. Amianthus in bright white bundles.
9. Amianthus in hard yellowiſh bundles.
10. White flexible amianthus.
11. Grey amianthus.
12. Mountain fleſh.
13. Mountain leather.
14. Mountain cork.

DIVISION II.

Compound Earths and Stones.

THESE cannot be diſtinguiſhed by ocular obſervation from thoſe of the former diviſion. As to the nature of their compoſition, they are formed of an homogeneous matter, almoſt always coloured, generally opaque, but ſometimes tranſparent; moſt of them are regularly cryſtallized. They are diſtinguiſhed into genera by form and colour. They are all very fuſible, and afford glaſs of various kinds. Their fracture is ſometimes vitreous, ſometimes ſcaly. In theſe ſubſtances nature has combined together earths, ſalts, and metals.

Bucquet divided theſe ſtones into two orders: Under the firſt he comprehended earths and ſtones compounded with water, which he characteriſed as products of that element. This order again he divided into two genera, namely, ochres and zeolite. Under the ſecond order he reckoned ſchorl, macles, trap, azure ſtone, fuſible precious ſtones, volcanic cryſtals, volcanic glaſs, and pumice ſtones: theſe eight kinds of ſtone he conſidered as formed by the action of fire. We have undertaken to give an account of the ideas of that celebrated chemiſt concerning the nature and claſſification of ſtones; but as the diſtinction between theſe two orders is not eſtabliſhed by a ſufficient number of concluſive facts, and as M. Bucquet himſelf offered them only as hints, we ſhall here give the hiſtory of theſe genera ſucceſſively, without dividing them into orders.

Genus I. *Ochres.*

Ochres are leſs eaſily diluted in water than clays; they are friable and ſoil the fingers; they are coloured by metallic matters, generally by iron. When expoſed to a ſtrong fire, they aſſume a deeper colour: violent heat melts them. They are uſed in painting.

Species.

1. Yellow ochre.
2. Red ochre, blood coloured.
3. Green ochre; Verona earth.
4. Brown ochre; Umber earth.

Genus

Genus II. *Zeolite.*

THE zeolite, firſt deſcribed by Cronſtedt, is a ſtone compoſed of needles diverging from a common centre. It neither gives fire with ſteel nor effervеſces with acids: When expoſed to fire it ſwells and produces a white opaque glaſs reſembling enamel. By diſtilling it in a retort, a conſiderable quantity of water is obtained. The reſidue, according to Bergman, conſiſts of ſiliceous, aluminous, and calcareous earth. Bucquet, who analyſed it, mentioned his having found in it a very little ſiliceous earth, and a particular kind of earth neither aluminous nor calcareous; which with the ſulphuric acid afforded a ſalt cryſtallized in ſmall ſhining plates, reſembling the boracic acid, and to which he thought proper to give the name of *zeolitous earth.* Theſe two earths are cryſtalliſed together by the help of water, which forms more than an eighth part of the compoſition: for, from an ounce of white zeolite, from the iſland of Ferro, M. Bucquet obtained a dram and an half of water *. The property of compoſing a jelly with various acids is not peculiar to it; azure ſtone, tin, and ſeveral iron ores, &c. are capable of a ſimilar compoſition †. Its origin and formation are unknown; abundance of it is found among the products of volcanoes.

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* See *les Memoires de Savans etrangers, Tome IX. p.* 576.

† M. Pelletier, apothecary, a diſciple of M. d'Arcet, has given in the *Journal de Phyſique* (1782, vol. XX. page 420.) a memoir on the analyſis of the zeolite of Ferro. He has found, by the moſt accurate experiments, that 100 grains of this ſtone contain 20 grains of aluminous, 8 grains of calcareous, and 50 of ſiliceous earth, and 22 grains of water. Conſult that memoir.—F.

noes. There is great plenty of in the iſle of Ferro. We are aquainted only with five kinds of it.

Species.

1. White zeolite, in tranſparent faſces.
2. White zeolite, in compact faſces.
3. Red zeolite.
4. Green zeolite.
5. Blue zeolite.

Neither the red, the green, nor the blue, has yet been examined.

Genus III. *Schorls.*

Schorl is a dark-coloured ſtone, generally violet, black, or green, very ſeldom white, ſufficiently brittle, and capable of giving fire with ſteel. It melts eaſily into a black opaque glaſs: it is, according to Bucquet, a combination of iron and aluminous earth. Bubbles have been found in the interior part of ſchorls, ſimilar to thoſe in the ſlags of glaſs-houſes.

Its origin is not very well known. Some people think it a volcanic product, becauſe it is often found in places which have felt the ravages of fire; but it is likewiſe found among matters which have been long expoſed to the action of water.

Species.

1. Violet ſchorl, in cryſtals.
2. Violet ſchorl in fibrous maſſes.
3. Black ſchorl, in priſms of 4, 6, 8, or 9 ſides,

with pyramids of 2, 3, or 4 faces, like the violet ſchorl.

4. Black ſchorl, in maſſes.
5. Green ſchorl, in lamellated maſſes.
6. White ſchorl, ſomewhat blueiſh.
7. Electric ſchorl, of a yellowiſh red, tourmaline.

Genus IV. *Macles.*

UNDER this name we comprehend a genus of ſtones, of a priſmatic form, opaque, dirty-coloured, and generally of a regular figure. By analyſing them M. Bucquet found them to be of a nature nearly reſembling that of ſchorls, namely, a compound of iron and aluminous earth.

Species.

1. Tetrahædral macle, the ſection of which exhibits the figure of the croſs. It is found in a kind of hard deep blue ſchiſtus of Brittany, to which it adheres ſtrongly: it is very brittle, and when broken exhibits on its tranſverſe ſection two blueiſh lines, cutting each other in the form of a croſs. Sometimes the middle of the priſm appears to be full of a matter reſembling that of a gangue.
2. Stones of the croſs; hexahædral priſms, articulated and croſſed in the middle like the arms of a croſs; theſe are found in the leaves of yellow mica; the two arms never croſs each other at right angles.

Genus

Genus V. *Trap.*

Trap is an hard ſtone fine grained, of a foliated fracture, and angular, like the ſteps of a ladder. Its colour is a deep green; approaching to black, often inclining to the colour of ochre; it is very ponderous, and gives fire with ſteel. It melts into a blackiſh glaſs, and is always covered with a kind of cruſt ſofter than itſelf. It is a compound of aluminous earth and iron: According to Bucquet iron exiſts in it, in the proportion of twenty-five pounds to the quintal, ſo that it might be conſidered as an iron-ore. M. Daubenton thinks it a ſchiſtus containing quartz in ſand. There is only one kind of trap known,—that which we have deſcribed.

Genus IV. *Azure Stone; Lapis Lazuli.*

This ſtone is claſſed along with the preceding genera, on account of its colour, the fineneſs of its grain, and the quantity of iron which, from an analyſis, it appears to contain.

Species.

1. Oriental azure ſtone.
2. Azure ſtone, of a pale blue, and often purpliſh.
3. Armenian ſtone, clouded with white and pale blue.

The azure blue uſed in painting, which is one of the moſt fixed and permanent colours known, is a preparation of this ſtone.

Genus

Genus VII. *Fuſible Cryſtal Gems.*

M. Bucquet, in conſequence of obſerving the differences of the various kinds of gems, or precious ſtones as to chemical properties, was induced to arrange them ſeparately under thoſe diviſions and orders to which they ſeemed moſt properly to belong. Thoſe which we are going to introduce in this place are evidently compounds. Bergman found them to conſiſt of various ſubſtances, ſuch as ſiliceous and aluminous earth, lime, and iron; all of them are fuſible, and compoſed of laminæ. Their fracture is lamellated.

Species.

1. Aqua-marina.
2. Emerald.
3. Cryſolite.
4. Ruby.
5. Vermilion, or Bohemian garnet.
6. Garnet.

Genus VIII. *Volcanic Cryſtals.*

Under this genus Bucquet comprehended all ſuch ſtones as are of a regular form, tranſparent, coloured, and ſimilar to cryſtal gems, but poſſeſs not the hardneſs or brilliancy of theſe laſt. They are found in cavities lined with ſmall ſparkling particles of the ſame nature, agglutinated together. They are met with in the neighbourhood of volcanoes. We admit three ſpecies of them.

Species.

1. Volcanic chryſolite; polyhædral cryſtals of a golden green.
2. Volcanic hyacinth, polyhædral cryſtals of an orange yellow.
3. Volcanic garnets. Theſe ſtrongly reſemble ſingle garnets; but they are irregular, and, as well as the two foregoing ſpecies, ſcattered among brilliant lavas.

Genus IX. *Pumice Stones.*

Most pumice-ſtones appear to be a collection of vitreous threads wound up together, nearly like yarn on a clue. The pumice-ſtone is really a combination of various ſubſtances which have been reduced to fuſion by the volcanic heat.

Pumice-ſtones may be divided into four ſpecies; each of which has many varieties.

Species.

1. White fibrous pumice-ſtone.
2. Coloured fibrous pumice-ſtone.
3. Light cellular pumice-ſtone.
4. Compact cellular pumice-ſtone.

Genus X. *Volcanic Glaſs.*

The glaſs melted and diſcharged by Volcanoes is a mixture of earthy and ſaline matters, coloured with iron or ſome other metallic ſubſtance. It is actually a natural chemical combination effected in the dry way.

Species.

1. Greeniſh cellular glaſs.
2. Blackiſh cellular glaſs, or in agglutinated threads.
3. Black glaſs, very fine and tranſparent; Iceland agate; lapis obſidianus of the ancients.

DIVISION III.

Mixed Earths and Stones.

THE characteriſtics of the ſtones of this eaſily diſtinguiſhed. We can diſcover merely by inſpection, of what different matters they conſiſt; and the more readily if we compare them with the ſtones of the two foregoing diviſions. We formerly obſerved, that, in order to analize them, it is firſt neceſſary to divide the various ſubſtances with an hammer; after this operation is performed, they are found to conſiſt of ſimple united with compound ſtones. If theſe mixed ſtones be expoſed unbroken to the action of fire, they will melt with more or leſs facility into a party-coloured glaſs, the nature and colours of which will be according to thoſe of the matters of which it is compoſed.

Theſe ſtones appear to have been formed by the union of the ſeveral ſubſtances of which they conſiſt, effected either by fire or water. On account of this circumſtance, Bucquet ſubdivided this third diviſion into two orders, as well as the foregoing. His firſt order comprehends mixed ſtones formed by water: the ſecond, ſuch as owe their compoſition to fire. As this ſubdiviſion is authoriſed by many more facts than that of the ſecond diviſion, we ſhall follow it with more confidence.

ORDER I. EARTHS *and* STONES *Mixed by* WATER.

Genus I. *Petro-ſilex*, or *Rockſtone*.

BY this name naturaliſts denote a ſtone of an intermediate hardneſs between ſoft ſtones and ſilex. M. Daubenton ranks it among the vitreous ſtones, becauſe it ſcintillates with ſteel, and its fracture is vitreous, though ſometimes rather ſcaly. Petro-ſilex has a kind of faint or half tranſparency like wax. It is duſky and deſtitute of brilliancy, and has even ſomewhat of the appearance of tallow; it is fine grained and very compact; it is found in large maſſes: it ſometimes diſplays layers variouſly ſhaded, diſpoſed one over another. The chemical characteriſtic by which M. Bucquet diſtinguiſhed it, was its diſpoſition to melt by fire into an opaque glaſs. It is far from being ſo eaſily diſcoverable to be a mixture as the following genera; it ſeems to poſſeſs the characteriſtics of compound ſtones [*]; and

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[*] I muſt here obſerve, that theſe characteriſtics of ſtones, derived from the manner in which they are affected by fire, are founded on experiments made by M. Bucquet, in conjunction with the Duke de Rochefoucault, in an excellent furnace for fuſion, conſtructed on purpoſe in the laboratory in which that illuſtrious cultivator of chemiſtry

for this reaſon we rank it at the head of the third diviſion: it forms a kind of of intermediate ſtep between this and the foregoing.

The form of its layers, the matters which they often contain, and ſtill more the maſſes in which it is accumulated in the bowels of the earth, ſhow plainly that it owes its origin to water.

Species.

1. Grey petro-ſilex.
2. Reddiſh.
3. Greeniſh.
4 Brown.
4. Black.
6. Spotted.
7. Veined.

Genus II. *Pudding-Stone.*

Pudding-Stone is a mixture of flints united by a cement of a different nature. That cement is either gritty or argillaceous, or ochreous; ſometimes it is hard, and reſembles ſilex.

Its formation is by no means equivocal; it is owing to water. Theſe ſtones are always found either on the ſea-ſhore, or in places which have been once covered with water, and afterwards left dry.

Species

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miſtry proſecutes ſo many reſearches for the improvement of the ſcience. I have re-examined moſt of the reſults of theſe experiments, which it is to be hoped will be one day communicated to the public: they will confirm the fine ſeries of experiments made by M. D'Arcet; and will add to them a number of facts, ſerving to ſupport Bucquet's arrangement of ſtones.

Species.

1. Sandy pudding-ſtone *.
2. Ochrous.
3. Argillaceous.
4. Siliceous.
5. Agatiſied ; ſuſceptible of the fineſt poliſh.

Genus III. *Granite.*

GRANITE is formed by the union of ſmaller or larger fragments of three different ſtony matters. Theſe are quartz, feldt ſpar, and mica.

On account of the quartz and feldt-ſpar which it contains, it gives fire with ſteel: its fracture is irregular and coarſe-grained : it is fuſible, but in various degrees, according as the three component matters are proportioned in the compoſition. It is ſuſceptible of a finer or an inferior poliſh according to the fineneſs of its grain and the hardneſs of its principles. Some ſpecies of it ſuffer alteration, and waſte away by the action of the external air. This laſt phenomenon enables us to diſtinguiſh ancient from modern granite. It has been ſubdivided into many ſpecies : But we ſhall reduce them all to the following †.

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* I have obſerved ſome of theſe in the very act of forming ; while they were, yet, ſoft and flexible, but, tough, and ſufficiently coheſive. —H.

† The natural hiſtory of granites has been much ſtudied by modern naturaliſts. M. Sauſſure, in his *Voyage des Alpes*, has communicated a number of new and important facts on this head. Granites are not invariably formed of a mixture of thoſe three ſtones. Some of them, inſtead of mica, contain ſchorl ; others contain both ſchorl and mica at the ſame time. A mixture of quartz and feldt-ſpar, without a

Species

1. White granite.
2. Grey.
3. Red.
4. Brown.
5. Green.
6. Black.
7. Dirty and friable granite, having ſuffered alteration by the action of fire.

Genus IV. *Porphyry.*

Porphyry is a ſtone ſpeckled with ſpots on a ground of red, or ſome other colour. It produces abundance of ſparks when ſtruck with ſteel.

It differs from granite in being harder and ſuſceptible of a much brighter poliſh: it ſeems to conſiſt of feldtſpar and ſchorl, united by a quartzoſe cement.

The paſte which conſtitutes the ground of porphyry is of a very fine cloſe grain; the other fragments united in it are generally much ſmaller than thoſe of granite. This ſtone is fuſible into a coloured glaſs. All the ſpecies of porphyry may be reduced to the following ſeven.

Species.

1. Red porphyry, with large ſpots.
2. Red porphyry, with ſmall ſpots.
3. Green porphyry, with large ſpots.
4. Green porphyry, with ſmall ſpots.

Species.

third ſubſtance, conſtitutes *granitine*: quartz and ſchorl compoſe *granitello*. See an account of theſe particulars in Sauſſure's *Voyage dans les Alpes*.—E.

Species.

5. Black porphyry, with large ſpots.
6. Black porphyry, with ſmall ſpots.
7. Coarſe porphyry, of a dirty red, almoſt without ſpots, nearly of the ſame nature with ſand-ſtone.

Genus V. *Ophites, or Serpentine.*

Pliny gave the name of *ophites* to a kind of ſtones ſpotted like a ſerpent's ſkin. Bucquet conſidered theſe as a kind of porphyry, but harder, of a more ancient formation, and having their component parts much more intimately united than the other kinds. They have likewiſe received the name of *ſerpentine*, or *hard ſerpentine.* On comparing this ſtone with porphyry, it appears that they are both compoſed of a quartzoſe paſte, with feldt-ſpar and ſchorl; but that in ſerpentine the fragments of feldt-ſpar and ſchorl are large and rhomboidal, while in porphyry they are very ſmall.

Serpentine gives fire with ſteel; its fracture is fine and half ſcaly; it melts in the fire.

The following are moſt of the ſpecies of ſerpentine which we have had occaſion to ſee.

Species.

1. Ophites of a deep green ground, with large white ſpots.
2. Dark green ophites, with oblong ſpots of a paler green.
3. Ophites reſembling the preceding ſpecies; its ſpots very ſmall, and ſcarcely viſible: Many

Species.

ſavage nations uſe it for money : it has received the name of *thunder ſtone*.

4. Brown ophites, with irregular oblong ſpots of a roſe-coloured white.

We are almoſt entirely ignorant of the circumſtances of the formation of ophites. We know not even whether it be owing to fire or water. But as they reſemble porphyry, we have for this reaſon placed them immediately after that genus.

ORDER II. EARTHS *and* STONES *Mixed by* FIRE.

Continuation of the Volcanic Products.

THE origin of theſe ſubſtances is well known ; they are never found but in the neighbourhood of volcanoes, or in places where volcanic fires have formerly exiſted. Beſides, they poſſeſs all the characteriſtics of products of fire. Theſe, together with the compound ſtones above deſcribed, will form a complete liſt of volcanic products.

We include not under this name all the matters which are found near volcanoes. Many of them are not altered by fire, ſuch as moſt of the ſtones above deſcribed, more eſpecially granite, clay, &c. as well as many ſaline ſubſtances, together with calcined, melted, ſublimated, and vitrified matters. They exhibit nothing very remarkable, and were we to deſcribe them here, it would occaſion an unneceſſary repetition. We ſhall in another place take notice of their exiſting in the neighbourhood of volcanoes, and of the alterations produced on them by ſubterraneous fire.

Genus I. *Volcanic Aſhes.*

The name of *volcanic aſhes* has been improperly given to a kind of pulverized earthy matters of various colours, which are found in the neighbourhood of volcanoes. They appear to be compoſed either of a mixture of ſubſtances diſcharged from the volcano, or of lavas altered by the action of air and water. Bucquet thought them to be combinations of iron and clay. They are generally attracted by the magnet. We know only two ſpecies of them.

Species.

1. Rapillo, a pulverized matter, of a blackiſh grey, which is found round the edges of volcanic craters.

Rapillo contains garnets and ſchorls, the form of which is ſtill diſcernible, though their angles have been ſoftened and incruſted by ſome matter in fuſion.

2. Puzzolana. This ſubſtance has received its name from the town of Puzzoli, where it has been made uſe of ſince a very remote period: it is an argillaceous earth impregnated with iron, and variouſly coloured according as it contains a greater or leſs proportion of the metal. There is grey, black, yellow, red, and brown puzzolana. It melts by fire into a black enamel. It is uſed to compoſe a kind of cement or mortar, which poſſeſſes the property of becoming hard in water. M. Faujas de St Fond found ſome of it in Vivarais. He thinks that it is formed by the al-

teration and attrition of porous lavas, and even of baſaltes. That philoſopher, in his reſearches on the nature of puzzolana, gives an account of the proceſſes neceſſary for building with it, both under water, and where it is to be expoſed only to the action of the air.

Genus II. *Lavas.*

THIS name is given to matters which have been melted and half vitrified by volcanoes. They are uſually ſcattered over the ſides of mountains, the interior parts of which are inflamed over with volcanic foci. They iſſue from the craters of volcanoes in burning ſtreams, which ſometimes overflow a wide extent of country, carrying deſtruction and deſolation wherever they direct their courſe. So conſiderable is their bulk, and ſo intenſe their heat, that they cool but very ſlowly, and are not quite cool till after ſeveral years. In cooling, they crack and ſeparate into maſſes, which are ſometimes of a regular form: and this ſeems to be the origin of baſaltes. In cabinets of minerals there is a great variety of theſe ſtones. They generally conſiſt of a grey paſte, of a lighter or a deeper ſhade; in grain and hardneſs ſubject to great varieties; with cryſtals or irregular fragments of ſchorl, garnet, glaſs, zeolite, &c. interſperſed; which makes a true mixture. It is impoſſible to point out any certain general properties of lavas; for they all differ from one another in grain, coheſion, hardneſs, colour, compoſition, &c. They are all in general very fuſible, and afford a kind of blackiſh enamel, like volcanic glaſs. M. Cadet found them to contain iron, copper, and ſiliceous and aluminous earth.

Bergman believed them to conſiſt of ſiliceous, aluminous, and calcareous earths, with a mixture of iron. Many lavas, and more particularly thoſe which are the moſt compact, poſſeſs the property of acting upon the magnetic needle.

Species.

1. Soft lava of various colours, containing cryſtals of black ſchorl.
2. Soft lava of various colours, containing cryſtals of green ſchorl.
3. Soft lava of various colours, with cryſtals of white ſchorl.
4. Reddiſh lava, with blackiſh cryſtals.
5. Yellowiſh ſaline lava.
6. Soft lava, with garnet cryſtals.
7. Porous lava, of a changing luſtre (*Fr. Chatoyant.*)
8. Porous grey lava, volvic ſtone.
9. Soft blackiſh lava, with white cryſtals.
10. Grey lava, ſomewhat compact, with duodecahædral, opaque cryſtals, or garnets altered by fire.
11. Ancient lava, very compact, of a blackiſh grey, and ſpeckled with ſpots of a deeper colour.

Genus III. *Baſaltes.*

There is nothing more inaccurate in the writings of naturaliſts, than their deſcriptions of baſaltes. Some have confounded both ſchorls and garnets with this ſubſtance. There is no where to be found an accurate definition of the word *baſaltes.* Some conſider them as products of volcanoes; others think them to be formed by water. The experiments and obſervations of Meſſieurs Deſmarets and Faujas de St Fond, induce us to prefer the former of theſe opinions. Regularity of form, abſolute opacity, and a conſiderable degree of hardneſs, ſuch as that it gives fire with ſteel, a grey aſhy colour, and an evident mixture of ſchorls, or ſmall fragments of vitrified matter, of a deeper colour than the maſs through which they are interſperſed, may be conſidered as the diſtinctive characteriſtics of baſaltes. They are likewiſe fuſible.

Among this genus there are ſtones of enormous bulk, and collected in vaſt maſſes, which appear to have been formed at ſome very remote period in antiquity. Such are, 1. The columns of the Giant's Cauſey in the county of Antrim in Ireland. 2. The rock of Pereneire near St Sandoux in Auvergne, which is very accurately deſcribed by M. Deſmarets. There are others regularly cryſtalliſed in ſmall priſms of three, four, or five faces, &c.: their form, ſize, and diſpoſition, are extremely various.

They are uſually arranged in regular order, one beſide another. No analyſis of them has yet been made from which any thing could be determined concerning their nature. They ſeem to be nothing but lavas apparently cryſtalliſed, in conſequence of the cracks which run through them in all directions while they are cooling *. Their arrangement and amazing varities

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* One theory which has been received concerning the formation of baſaltes, is, that when a ſtream of lava pours into the ſea, the impulſe of the water cauſes it to contract and ſplit into regular figures. But

rieties give conſiderable weight to this opinion: it likewiſe appears, that water inſinuating itſelf into the chinks, depoſites in them different kinds of earth, and alters the correſponding ſides of the baſaltic columns: and this ſeems to be the cauſe that produces the yellow or brown cruſts with which they are covered.

Species.

1. Baſaltes in very long polygon priſms, not terminating in regular pyramids.
2. Baſaltes in ſhort truncated priſms, of three, four, five, or ſeven faces.
3. Baſaltes in ſhort polygon priſms, terminating on the upper end in a concavity, at the lower in a convexity; articulated baſaltes.
4. Small baſaltes, quadrangular, triangular, &c.; formed by the fracture of the larger columns, and united in the ſame group with them[*].

Genus IV. *Scoriæ of Lavas.*

The melted matter of which lavas conſiſt is a mixture of various heterogeneous ſubſtances, differing in denſity

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But the ingenious M. Houel, in his *Voyage Pittoreſque, &c.* ſhows this theory to be inconſiſtent with facts. He propoſes another, in which he aſcribes the formation of baſaltic columns to the heterogeneity of the matters of which lavas are compoſed. An ingenious theory! but not ſufficiently confirmed by facts.—H.

[*] For the hiſtory of theſe ſtones, and all the other products of volcanoes, ſee an excellent work entitled *Mineralogie des Volcans, par M. Faujas de St Fond, Paris,* 1784.—F.

Of all the above ſpecies of baſaltic columns, there are ſpecimens to be ſeen in the *King's Park*, near Edinburgh.—H.

denſity and gravity. As it is ſlowly cooled, theſe ſeveral ſubſtances are ſeparated, according to their gravities. Hence the ſcoriæ of lavas. Theſe are ſpongy ſubſtances which have not been ſo thoroughly melted as the lava, and whoſe levity raiſes them to the ſurface of the maſs. In other reſpects they appear to be of the ſame nature with lava; the only difference being, that they are a more imperfect mixture. Scoriæ, as well as lavas, are found to contain ſchorl and garnet cryſtals.

Species.

1. Ponderous volcanic ſcoriæ, of a compact texture.
2. Black cellular volcanic ſcoriæ.
3. Black ſpongy volcanic ſcoriæ.
4. Black volcanic ſcoriæ, twiſted like a rope.
5. Yellow ochreous volcanic ſcoriæ.
6. Reddiſh volcanic ſcoriæ.

The two laſt ſpecies plainly appear to have ſuffered alteration from the contact of air, water, and acid vapours.

Such was the claſſification of earths and ſtones which Bucquet thought proper to adopt in the years 1777 and 1778. Great progreſs has ſince been made in the chemiſtry of mineralogy. Stones are now analyſed in almoſt every laboratory. Meſſrs Bayen, D'Arcet, Monnet, de Morveau, Sage, Mongez, and Pelletier, in France; Scheele and Bergman in Sweden; Achard, Bindheim, and Hupſch, at Berlin; de Sauſſure in Switzerland; Woulfe, Withering, and Kirwan, in England, have examined a great number of earths and ſtones: and in conſequence of theſe analyſes, the claſſification ſication of earths and ſtones muſt undergo a conſiderable change. Two of thoſe chemiſts have therefore publiſhed new ſyſtems of mineralogy, in which their arrangements are founded on the nature of the component principles of minerals. But their methods are totally different from that of Bucquet, who ſought to aſſociate exterior characteriſtics with chemical properties. Bergman and Kirwan have paid no regard to phyſical qualities; the nature, the quantity, and the proportion of the component principles are the particulars on which they found their arrangements. Their ſyſtem, though it may contribute greatly to the advancement of chemical knowledge, cannot teach us to diſtinguiſh ſtones by their appearance and ſenſible properties. It was therefore abſolutely neceſſary to give, as we have done, ſome phyſical method, before entering on the examination of theſe ſyſtems. The one throws light on the other; and they may thus be equally uſeful to the ſtudent of mineralogy.

§ II. BERGMAN's *Chemical arrangement of Earths and Stones*[*].

BERGMAN, after ſhowing that external properties, if judiciouſly ſelected, may be *of uſe* in forming a claſſification of minerals, but are not of themſelves *fully adequate* to that purpoſe, eſtabliſhes his principal diviſions of claſſes and genera on the compoſition and intimate qualities of thoſe bodies. Every mineral is arranged by that principle which is the moſt powerful, or the moſt copious in its compoſition: all minerals, or foſſils, are in this ſyſtem divided into four claſſes; ſalts, earths, bitumens, and metals. We ſhall here take notice of none but the earths.

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[*] This ſection is an extract from Bergman's work, publiſhed in French, by M. Mongez, under the title of *The Mineralogiſt's Manual, &c.* F.——There is an Engliſh tranſlation of it by Dr Withering.—H.

Bergman acknowledges five different kinds of ſimple earth; terra ponderoſa, lime, magneſia, clay, and ſiliceous earth[*].

He firſt examines each of theſe as pure earths, though none of them is ever found ſuch in nature: he obſerves, that theſe five earths combine into twenty different ſpecies, ten of two, ſix of three, three of four, and one of the whole five. But he ranges among the ſpecies of earths all ſuch of their combinations with acids as are not ſoluble in one thouſand times their own weight of boiling water; and thoſe ſpecies are thus increaſed to a vaſt number. Beſides, two compound earths, though made up of the ſame component principles, may differ widely as to the proportion in which theſe principles exiſt in them; even ſo much as to be eſſentially different in their nature. Theſe are the grounds on which Bergman and his commentator the Abbé Mongez, have diſtinguiſhed earths into different ſpecies,

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[*] Three of theſe five kinds of earth appear plainly to poſſeſs ſaline properties, namely, *barytes* or ponderous earth, magneſia, and lime; and we therefore reſerve the hiſtory of them to the ſecond part of the work. Bergman, whoſe intention was to divide ſtones according to their principles, was obliged to rank them among the earths, becauſe they are often united with each other. Many of the ſubſtances which that illuſtrious chemiſt has placed among ſtones, come in our method to be conſidered as ſalts.—F.

ſpecies; for Mongez has made conſiderable additions to the labours of the Swediſh chemiſt. The following are the ſpecies into which they divide each of the primary earths.

Ponderous Earth *.

Species.

I. Pure ponderous earth. This is no where to be found in nature; it is obtained, as we ſhall afterwards ſee, by decompoſing ponderous ſpar.

II. Aërated ponderous earth; a combination of terra ponderoſa with the aërial acid. This compound has not hitherto been found in nature: Bergman thinks that it may exiſt in water in a ſtate of ſolution †.

III. Vitriolated ponderous earth; ponderous ſpar: a combination of ponderous earth with the vitriolic acid. Abundance of this ſubſtance is found in mines. The Bologna ſtone is a variety of it.

IV. Vitriolated ponderous earth, containing petroleum, mixed with ſelenite, alum, and ſiliceous earth; the hepatic ſtone of Cronſtedt. This is a bright yellow, brown, or black ſparry

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* We ſhall here follow the denominations of Bergman. It will be eaſy to refer the ancient names both of earthy baſes and of the acids united with them, to the new and methodical denominations which we ſhall give thoſe bodies in the hiſtory of ſaline matters. See the end of this volume, and the ſecond.—F.

† A natural compound preciſely of this ſpecies has been found in England ſince the death of Bergman. See the extract from Kirwan's Mineralogy.—F.

ſparry ſubſtance; ſtrong ſmelling, and not effervеſcent with acids. A quintal of this natural compound contains, according to Bergman, 33 parts of ſiliceous earth, 29 of pure terra ponderoſa, and 5 of clay, beſide lime, water, and vitriolic acid.

Lime.

Species.

I. Pure or quick-lime. Bergman knew not whether this ſubſtance exiſted in nature.

II. Aërated lime; chalk, or calcareous earth; a combination of lime with the aërial acid. It often contains marine ſalt of magneſia, calcareous marine ſalt, clay, and ſiliceous earth or iron. In the bowels, or on the ſurface of the earth, it conſtitutes lac lunæ, congelations, calcareous ſtones, marbles, calcareous ſpars, concretions or ſtalactites, &c.

III. Bituminous aërated lime, or lime impregnated with petroleum; ſwine-ſtone. It is found in France at Villers-Cotterets, Plombieres, and Ingrande in Anjou; at Rattwik in Dalecarlia, Kinekulle in Weſtrogothia, Kraſnaſelo in Ingermania, in Portugal, in Sweden, &c. If violently rubbed, or heated, it diffuſes a fetid ſmell, which ſometimes affects the noſtrils in the ſame manner as cat's urine; and ſome authors have therefore given it the name of *lapis felinus*. It effervеſces with acids, decrepitates, and loſes its ſmell and colour in fire. When diſtilled in large quantities, it affords, 1. A fetid liquor, which turns the ſyrup of violets green, and efferveſces with acids; 2. A blackiſh oil, of a ſtrong ſmell, reſembling that which is obtained from pit-coal; 3. Concrete volatile alkali. The reſidue contains a little marine ſalt. This ſubſtance owes its peculiar properties to the bitumen mixed with it.

IV. Fluorated lime; fluor mineral, or vitreous ſpar. A combination of lime with the ſpathoſe or fluoric acid, with a mixture of clay and ſiliceous earth, and a little of the marine acid.

V. Lime ſaturated with a peculiar acid, probably metallic *; ponderous ſtone; Swediſh *Tungſten*. This is the weightieſt of all ſtones. It is found in ſmall yellow or red grains in the mines of Baſtnaes, near Kitterhute in Weſtmania; at Marienburgh and Altenburgh in Saxony; it is ſparry, bright, and whitiſh. It is often confounded with white tin ore. It ſcarce yields to the action of fire, and is vitrifiable only at the ſurface: it is not ſoluble in boiling water; the vitriolic acid ſeparates the lime: by diſſolving it in volatile alkali, precipitated by the nitrous acid, a white powder is obtained, which is the peculiar acid diſcovered by Scheele. In order to recognize and diſtinguiſh it from other ſtones, we muſt firſt reduce it to powder, and then pour upon it a

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* Found to be ſo. See Scheele's Eſſays, and De Luyart's on Wolfram, both tranſlated into Engliſh.—H.

due quantity of the nitrous or of the marine acid. This mixture, when gently heated, aſſumes a fine yellow colour. (See *Le Journal de Phyſique*, 1783, *tome* 22.)

VI. Aërated lime, contaminated * with a ſmall mixture of muriatic magneſia, or marine ſalt of magneſia.

VII. Aërated lime, contaminated with clay; falſe marl.

VIII. Aërated lime, contaminated with ſiliceous earth. Some hewing ſtones and marbles give fire with ſteel, on account of the fragments of ſilex or quartz which they contain.

IX. Aërated lime, contaminated with a mixture of argillaceous and ſiliceous earth; perfect marl.

X. Aërated lime, contaminated with iron and manganeſe: falſe white iron ore; black and duſty, or hard, red, or whitiſh. The mines of Hallefors exhibit theſe varieties †.

Magneſia.

I. Pure magneſia. This is always a product of art.

II. Aërated magneſia, diſſolved in water ſaturated with aërial acid.

III. Aërated

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* The word contaminated, *inquinatus*, is uſed by Bergman to denote the mixture of two or more earths, when no real combination takes place. We ſhall therefore ſometimes ſubſtitute the word *mixed* in its place.—F.

† All theſe ſpecies are ſaline ſubſtances, which will be deſcribed in the hiſtory of ſalts.—F.

Species.

III. Aerated magneſia, mixed with ſiliceous earth. It ſcintillates and effervеſces.

IV. Magneſia, intimately combined with clay and ſiliceous earth; ſteatites, Briançon chalk, ſoap-ſtone, lapis ollaris, ſerpentine, lapis nephriticus.

V. Magneſia, combined with a conſiderable portion of ſiliceous earth, and a ſmaller quantity of calcareous and argillaceous earth, and contaminated with calx of iron. Aſbeſtos; mountain cork; mountain leather; amianthus. Bergman found a quintal of amianthus to contain 64 parts of ſiliceous earth, $18\frac{3}{5}$ths of magneſia, $6\frac{9}{10}$ths of lime, 6 of vitriolated ponderous earth, $3\frac{3}{10}$ths of clay, and $1\frac{1}{5}$th calx of iron; a quintal of aſbeſtos afforded 67 parts of ſiliceous earth, $16\frac{4}{5}$ths of magneſia, 6 of clay, 6 of lime, $4\frac{1}{5}$ of calx of iron.

VI. Magneſia mixed with argillaceous and ſiliceous earth, and with pyrites; a kind of ore of alum deſcribed and analyſed by M. Monnet, (*Syſt. de Mineralogie, genre* 9. *page* 161).

VII. Magneſia mixed with argillaceous and ſiliceous earth, pyrites, and petroleum; magneſian aluminous ſchiſtus.

Clay.

I. Pure clay. It is precipitated from alum by aërated volatile alkali.

II. Clay mixed with ſiliceous earth. Porcelain earth; Chineſe kaolin. Solid clay from Saint-

Species.

Iriez in the Limouſin, from Japan, and from Saxony. Pulverulent clay from Weſtmania, Boſerap, and China. Theſe earths are often mixed with mica. Clays for potteries and delft-ware are coarſer, but of a ſimilar nature.

III. Clay mixed with iron and ſiliceous earth. Boles or bolar earth, grey, yellow, red, brown, and black. Theſe, when waſhed, become terræ ſigillatæ. Common clays, of a green, blue, or red colour, are of this ſpecies.

IV. Clay mixed with ſiliceous and calcareous earths. Argillaceous marl; pipe clay; agaric mineral or foſſil.

V. Clay mixed with ſiliceous and magneſian earth. Lemnian earth; fuller's earth; ſoap-ſtone; ſmectites. Bergman obtained from Lemnian earth, Hampſhire clay, and Engliſh fuller's earth, a conſiderable quantity of ſiliceous earth, about $\frac{1}{5}$th of clay, and as much aërated lime, with $\frac{1}{30}$th of aërated magneſia, and the ſame quantity of oxide of iron. He gives to theſe earths the generic name of *lithomarga*.

VI. Clay contaminated with ſulphur and vegetable alkali: alum ore of Tolfa and Solfaterra. Bergman takes it to be a volcanic product.

VII. Clay mixed with ſiliceous earth, pyrites, and petroleum; aluminous ſchiſtus. It is found in Italy; in the diſtrict of Liege; in Sweden, and in Jemteland. Black crayons, ſuch as thoſe from Bechel near Seez in Normandy, and the ampelites, are of this ſpecies. Tripolis

Species.

lis are of the ſpecies of aluminous ſchiſti, more or leſs burnt. Such are thoſe of Poligné in Normandy and of Menat in Auvergne.

M. Mongez comprehends under this ſpecies, thoſe ſchiſti which contain much clay, and more or leſs ſiliceous earth and bitumen. Moſt of them contain likewiſe a mixture of calcareous earth, and efferveſce with acids. The proportions in which the component principles are mixed in theſe ſchiſti are extremely various. Some of them are ſo bituminous, that they burn with flame; others are full of pyrites, and efferveſce in the air; ſome again are exceſſively hard, and give fire with ſteel. M. Mongez admits five varieties: 1. Hard argillaceous ſchiſtus, or writing ſlate: 2. Soft argillaceous ſchiſtus, or ſlate for roofing houſes: 3. Soft ſiliceous ſchiſtus, uſed in poliſhing metals: 4. Hard ſiliceous ſchiſtus, uſed for whetting razors; ſcythe-ſtone: 5. Hard calcareous ſchiſtus, which makes an indifferent lime, ſuch as that of Allevard in Dauphiny.

VIII. Clay combined with nearly half its weight of ſiliceous earth, a little aërated lime, and ſome oxide of iron; cryſtal gems. Bergman's fine diſcoveries concerning the nature of cryſtal gems, which, from their exceſſive hardneſs and apparent inalterability, were formerly thought not to be ſuſceptible of a chemical analyſis, have been confirmed by the experiments of Meſſrs Margraf, Gerhard, and Achard.

The

The following is the reſult of Bergman's analyſis of the five cryſtal gems, which are varieties of the ſpecies we are now conſidering.

	Clay.	Silic.	Lime.	Iron.	
Oriental emerald contains	60	24	8	6	100dth parts.
Oriental ſapphire -	58	35	5	2	
Saxon topaz - -	46	39	8	6	
Oriental hyacinth -	40	25	20	13	
Oriental ruby -	40	39	9	10	

The means employed by this ingenious chemiſt for reſolving ſtones into their component principles, though very ingenious are very ſimple. (See *le Journal de Phyſique*, 1779, *tome* 14. *p.* 268 ; *tome* 21. *p.* 56 *et* 101) *.

IX. Clay combined with a portion of ſiliceous earth, equal to more than half the weight of the whole maſs, with a very ſmall quantity of aërated lime and ſome iron ; garnet, ſchorl, tourmalin. In theſe ſtones the proportion of the iron varies. See the analyſis of the Tourmalin of Tyrol, *by M. Muller, Journal de Phyſique, tome* 15. *p.* 182. *ann.* 1780.

X. Clay ſlightly combined with half the weight of the maſs, or rather more, of ſiliceous earth, and a ſmall quantity of lime ; zeolite. M. Mongez conſiders the azure ſtone, *lapis lazuli*, as a zeolite. M. Margraaf found a ſmall quantity of gypſum, ready formed in the *lapis*.

XI.

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* Or rather Bergman's Eſſays.—H.

Species.

XI. Clay combined with a conſiderable quantity of ſiliceous earth and a little magneſia; talc, mica. The proportion in which the princiciples exiſt in this ſtone is not yet perfectly determined.

Genus V. *Siliceous Earth.*

I. Pure ſiliceous earth. This is obtained by melting white quartz with four parts of fixed alkali, diſſolving the whole in diſtilled water, and precipitating the earth with an acid. The precipitated earth is then waſhed and thoroughly dried.

II. Siliceous, united with a very ſmall proportion of argillaceous and calcareous earth: The ſeveral varieties of rock-cryſtal, of quartz, and of grit-ſtone.

III. Siliceous, united with argillaceous earth. Hydrophanes chalcedony, or *oculus mundi*: according to M. Gerhard of Berlin, this ſtone contains a greater quantity of clay than of ſiliceous earth. Opal: M. Mongez conſiders cat's eye, fiſh's eye, and giraſol, as varieties of this ſtone. To theſe three he adds agate and its varieties; cacholong, carnelian, ſardonyx, gun-flint, and jade. They have not as yet been analyſed with ſufficient accuracy.

IV. Siliceous earth united with clay ſtrongly impregnated with iron; jaſper. M. Mongez conſiders the ſinople as a variety of the jaſper.

V. Siliceous earth united with ſuch a quantity of martial earth as renders it ponderous; falſe jaſper. M. Mongez calls this ſtone a metallic quartz. He diſtinguiſhes it into the black coloured by iron, and the red-coloured by copper.

VI. Siliceous united with argillaceous earth, and a little lime; petroſilex. This ſtone ſometimes gives fire with ſteel, and effervеſces with acids. It melts in a ſtrong fire.

VII. Siliceous earth united with clay, and a little magneſia; feldt-ſpar. It ſuffers a change of colour, and melts in the fire. Air does not decompoſe it. It gives fire with ſteel, and breaks at every ſtroke.

VIII. Siliceous earth, united with magneſia, aërated and fluorated lime, and a portion of oxide of copper and iron; praſe, chryſopraſe. Bergman gives the compoſition of this ſtone from an analyſes of it by M. Achard.

I. APPENDIX.

Bergman, in his firſt appendix treats of mineral ſubſtances mechanically mixed or united, in ſuch a manner that the principles of the mixture or compoſition may be at once diſtinguiſhed by ocular obſervation. We ſhall mention none but mixtures of earths; ſuch are the ſtones known by the name of rocks, *ſaxa*. M. Mongez, who has made conſiderable additions to what

Bergman

Bergman had done on this head, diſtinguiſhes theſe ſtones or rocks into two genera. 1. The firſt, thoſe whoſe parts are not united by any cement, but ſimply adhere by juxta-poſition. Theſe are formed by the agglutination of a number of fragments. He diſtinguiſhes them into three ſpecies,—granite, gneis of Saxony, and horn-ſtone. 2. His ſecond genus comprehends ſuch mixed ſtones as have their parts incruſted in a common cement; as is the caſe with the four ſpecies of porphyry, ophites, or ſerpentine, breccia, and pudding ſtone. We ſhall here give the varieties of theſe ſtones acknowledged by this naturaliſt.

I. GRANITE is a compoſition formed by the union of quartz, feldt-ſpar, mica, ſchorl, and ſteatites, mixed in various proportions; conſiſting ſometimes of two of theſe ſubſtances, ſometimes of three, and ſometimes of four. Quartz is always the baſe.

Variety I. Granite of two ſubſtances; granitine.

A. Quartz and feldt-ſpar.
B. Quartz and ſchorl.
C. Quartz and mica.
D. Quartz and ſteatites.

Variety II. Granite of three ſubſtances.

Quartz, feldt-ſpar, and mica. This is the moſt common, the moſt plentiful, and the moſt varied of all.
B. Quartz, mica, and ſchorl.
C. Quartz, ſchorl, and ſteatites.

Variety III. Granite of four ſubſtances.
A. Quartz, feldt-ſpar, ſchorl, and mica.
B. Quartz, feldt-ſpar, ſchorl, and ſteatites.

II. GNEIS is a mixture of quartz in grains, and mica in a greater or leſs proportion, with a conſiderable quantity of clay or ſteatites, which conſtitutes the baſe of the ſtone. This ſtone is foliated like the ſchiſtus. Expoſure to the air ſoon alters and waſtes it down, becauſe the clay abſorbs moiſture. Many varieties of the gneis are found on the Alps of Dauphiny.

III. HORN-ROCK is a compact ſtone, conſiſting of very minute particles of an earthy aſpect, and exhibiting over its ſurface ſparkling points of mica. When moiſtened or ſtruck, it diffuſes a clayey ſmell. It hardens in the fire like clays, and when expoſed to a very ſtrong heat, melts into a blackiſh ſcoria or a black glaſs. Its colours are extremely various. M. Mongez thinks the Swediſh *trapp* a variety of the horn-ſtone.

IV. PORPHYRY ſeems to be compoſed of a fine hard paſte of the ſame nature with red jaſper, containing either irregular or cryſtalline grains of quartz, of white or reddiſh feldt-ſpar, and ſometimes of green or black ſchorl.

V. OPHITES, or ſerpentine, is a ſpecies of porphyry, of a green paſte, and greeniſh white ſpots. The ſpots of the ophites are generally oblong; whereas thoſe of porphyry are ſquare or rhomboidal. The thunder-ſtone is a variety of this ſpecies.

VI. Breccia, from the Italian word *briccia*, a crumb or fragment. This is a mixed ſtone of a much later formation than any of the above, formed of the ruins of the primary mountains, of irregular worn pieces of ſilex, &c. united by a common cement. M. Mongez makes no ſpecific diſtinction between breccias and pudding-ſtones; but gives to the latter a compound name, indicating the nature both of their fragments and of their cement. He diſtinguiſhes theſe ſtones into eight varieties: The calcareo-calcareous breccia, under which denomination both the breccia properly ſo called and the lumachello are included; the ſiliceo-ſiliceous breccia, or the pudding-ſtone*; the breccia conſiſting of calcareous and ſiliceous fragments, with a calcareous cement; the breccia with ſiliceous cement, and fragments of the calcareous and ſiliceous genus; the arenario-ſiliceous breccia,—of this variety is the grey ſtone of Chartres; the breccia with a cement and fragments of jaſper; the breccia with a cement and fragments of porphyry; and the volcanic breccia.

II. APPENDIX.

Volcanic Products.

M. Mongez, with Bergman, divides volcanic products into ſuch as are formed by fire, and ſuch as owe their origin to water. The laſt are nothing but earthy matters, which having been diſſolved or ſuſpended in water, are by it depoſited in places adjacent to volcanoes, and among volcanic products: of this kind are the calcareous and ſiliceous incruſtations, as well as the zeolites which are often found among volcanized ſubſtances.

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* According to this nomenclature, the firſt of the two names affixed to the breccia, expreſſes the nature of its cement; the ſecond, that of its fragments.—F.

M. Mongez divides the genuine products of volcanoes into three orders: 1. Earthy ſubſtances, but little altered by fire; ſuch as calcareous matters, clays, garnets, hyacinths, ſchorls, and mica. 2. Earthy ſubſtances which have been burnt and calcined; ſuch as volcanic aſhes or rappillo, and puzzolana, the tufa, the peperino of the Italians, pumice-ſtone, and the white earth which covers ſolfatara. 3. Earthy ſubſtances which have been in a ſtate of fuſion, or lavas; and of theſe he admits ſeveral kinds,—the ſpongy lava, the compact lava, the lava in ſtalactites, and volcanic glaſſes. After theſe diviſions, he mentions ſuch earthy volcanic products as are of an uncertain origin. Under this order he reckons particularly volcanic ſchorls, and ſtill more baſaltes, which he takes to be maſſes of trapp ſoftened by the humid vapours of volcanoes, and ſlowly dried after theſe have ceaſed to exhale.

§ III. *Chemical Claſſification of Earths and Stones, by Mr* KIRWAN.

In the year 1784, Mr Kirwan, a celebrated chemiſt of London, publiſhed a work on mineralogy; in which he gives a general claſſification of minerals, founded on their chemical properties or combinations. The firſt part of his work contains earths and ſtones. He gives inſipidity, dryneſs, fragility, incombuſtibility, and inſolubility, as the characteriſtic properties of theſe ſubſtances. With Bergman, he diſtinguiſhes five genera of ſimple earths,—calcareous earth, ponderous earth or barytes, magneſia or muriatic earth, argillaceous earth, and ſiliceous earth. From a chemical analyſis, he arranges all known earths and ſtones under theſe five genera.

CALCAREOUS GENUS.

To this he refers twelve ſpecies.

Species.

I. Calcareous earth, not combined with any acid; virgin lime of volcanoes. *Falconer on Bath Waters, vol.* i. *p.* 156, 157; *Monnet. Mineral. p.* 515.

II. Calcareous earth, combined with aërial acid. Its varieties, which he arranges in two ſeries, are tranſparent calcareous ſpar, opaque ſpar, ſtalactites, tophi, incruſtations, petrifactions, agaric mineral or ghur, chalk, limeſtone, and marbles. *Bayen, Journal de Phyſique, tome* ii. *p.* 496.

III. Calcareous earth combined with the vitriolic acid, gypſum, ſelenite, or plaſter *. He admits two ſeries; the tranſparent and the opaque.

IV. Calcareous earth combined with the ſparry acid, fluor ſpar, petuntze of Margraf. Series

I.

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* Mr Kirwan claſſes many earthy ſalts among ſtones; though they be even one half more ſoluble than the moſt ſoluble ſtones.—F.

I. Tranſparent fluor ſpars: II. Opaque fluor ſpars.

V. Calcareous earth combined with the acid of tungſten. Tungſten or ponderous ſtone. *Woulfe, Phil. Tranſ.* 1779, *p.* 26.; *Scheele's Eſſays.*

VI. Aërated calcareous earth, mixed with a diſcernible quantity of magneſia. Var. I. Compound ſpar, deſcribed by *Mr Woulfe, Phil. Tranſ.* 1779, *p.* 29. II. Creutzwald ſtone, analyſed by *M. Bayen*†, *Jour. de Phyſ. tome* xiii. *p.* 59.

VII. Aërated calcareous earth, mixed with a diſcernible quantity of clay. Var. I. Calcareous marl. II. Traveſtino, margodes, ſtony marl. *Ferber's Travels in Italy, p.* 117, 119.

VIII. Aërated calcareous earth, mixed with a diſcernible quantity of ponderous earth; barytic marl of Derbyſhire.

IX. Aërated calcareous earth, mixed with a diſcernible portion of ſiliceous earth. Var. I. Stellated ſpar. II. Calcareous grit; hard free-ſtone, *Moilon. Monnet, Mineralogy, p.* 116.

X. Aërated calcareous earth, mixed with a ſmall quantity of petroleum. Swine-ſtone.

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† It would be ſuperfluous to give here the proportions in which the ſeveral principles are united in theſe ſtones, as we will have occaſion to mention them in the chemical hiſtory of ſalts. We ſhall give the proportions only in Mr Kirwan's two laſt genera, which we conſider as genuine earths.—F.

Species.

XI. Aërated calcareous earth, mixed with a diſcernible quantity of pyrites; *pierre de St. Ambroix*, analyſed by the *Baron de Servieres*, *Journ. de Phyſ. tome* xxi. *p.* 394.

XII. Calcareous earth, mixed with a diſcernible portion of iron. Var. I. Aërated calcareous earth impregnated with iron, *Rinman*, *Mem. de Stock.* 1754. II. Tungſten impregnated with iron, *Cronſtedt*, *Mem. de Stock.* 1751.

To theſe twelve ſpecies of calcareous earth, Mr Kirwan adds ſix ſpecies of compound ſtones, in which calcareous earth predominates. 1. Mixtures of the ſimple calcareous ſpecies, ſuch as ſelenite and chalk, vitreous ſpar and tungſten. 2. Compounds made up of the calcareous and barytic ſpecies. Of this kind is a yellow ſtone of Derbyſhire, formed of chalk with ſmall lumps of ponderous ſpar. 3. Compounds of the calcareous and magneſian ſpecies; white marble mixed with ſteatites, the *pietra telchina*, and the *verde antico.* 4. Compounds of the calcareous and the argillaceous ſpecies, of chalk and ſchiſtus; ſuch as the green campan of the Pyrences, the red campan, Florence marble, the griotte, the amandula, the cipolin of Rome (ſee *Bayen*, *Journ. de Phyſique*, *tome* xi. *p.* 499. 801, *et tome* xii. *p.* 51, 56, *et* 57.); of chalk and mica, as the cipolin marble of Autun, the macigno, the pietra bigia, and the columbina or turchina of the Italians. 5. Compounds of the calcareous and the ſiliceous ſpecies; ſcintillating marbles, marble with a mixture of lava. 6. Laſtly, compounds of calcareous earth, with two or more of the other genera; ſuch as calcareous porphyry, and the lime-ſtone mixed with mica.

BARYTIC GENUS.

Under this genus he reckons ſix ſpecies.

Species.

I. Ponderous earth combined with the aërial acid. A ſtone found by Dr Withering on Alſton Moor in Cumberland.

II. Barytes combined with the vitriolic acid. Ponderous ſpar.

III. Barytes combined with the ſpathoſe acid. This ſubſtance exiſts not in nature, but is a product of art.

IV. Barytes combined with the acid of tungſten. This is obtained in the ſame manner as the preceding.

V. Aërated barytes, mixed with a diſcernible quantity of ſilex and iron. Bindheim.

VI. Ponderous ſpar, mixed with ſilex, mineral oil, and earthy ſalts. Hepatic ſtone, white, grey, yellow, brown, or black.

MURIATIC OR MAGNESIAN GENUS.

Mr Kirwan reckons eight ſpecies of this genus, arranging under it both thoſe earths and ſtones in which magneſia predominates, and thoſe which, though containing more ſilex than magneſia, yet exhibit all the characteriſtics of the magneſian genus.

Species.

I. Magneſia combined with the aërial acid, and mixed with other earths. Var. I. Mixed with ſilex; *ſpuma maris*. The Turkiſh tobacco-pipes, and the Canadian pipe, are compoſed of this ſubſtance. II. Mixed with calcareous earth and iron; olive-coloured and bluiſh earth near Thionville. III. Mixed with clay, talc, and iron; greeniſh yellow Sileſian earth.

II. Magneſia combined with the aërial acid, with above four times its weight of ſilex, and a ſmall proportion of clay. Var. I. Steatites. II. Lapis ollaris.

III. Aërated magneſia combined with ſilex, calcareous earth, and a ſmall proportion of clay and iron. Var. I. Fibrous aſbeſtos. II. Coriaceous aſbeſtos; mountain cork.

IV. Aërated magneſia, combined with ſilex, aërated calcareous earth, barytes, clay, and iron. Amianthus.

V. Pure magneſia, combined with a quantity of ſilex, more than equal to its own weight, a third part of clay, nearly a third of water, and one or two tenths of iron. Serpentine, *lapis nephriticus*, Italian gabro.

VI. Pure magneſia, combined with twice as much ſilex, and leſs than an equal quantity of clay. Venetian talc, Muſcovy talc.

VII. Magneſia combined with the ſparry acid. This ſubſtance is not found in nature.

VIII. Magneſia combined with the acid of tungſten. This ſubſtance is not known to exiſt in nature..

To theſe eight ſpecies, Mr Kirwan adds five others, compounds in which magneſia predominates. 1. Compounds of the ſeveral ſpecies of magneſia with one another; ſteatites and talc, Briançon chalk; ſerpentine with ſteatites or aſbeſtos. 2. Compounds of the magneſian with the calcareous ſpecies; red or yellow ſerpentine, with ſpots of white calcareous ſpar, *potzovera;* the black is the *Nero di prato*, and the green the *verde di ſuza* of the Italians. 3. Compounds of the magneſian and the barytic ſpecies; ſerpentines with ſpots or veins of ponderous ſpar. 4. Compounds of the magneſian and the argillaceous ſpecies; ſteatites mixed with clay, mica, or ſchiſtus. 5. Compounds of the magneſian with the ſiliceous ſpecies; ſerpentine veined with quartz, feldt-ſpar, or ſchorl.

ARGILLACEOUS GENUS.

Mr Kirwan reckons fourteen ſpecies of this genus.

Species.

I. Clay ſaturated with the aërial acid; *lac lunæ*, according to Schreber's analyſis.

II. Clay combined with the aërial acid, and mixed with ſilex and water; potter's clay, pipe and porcelain clay, &c.

III. Clay ſaturated with the vitriolic acid; embryon alum in ſcales like mica. *Baumé.*

IV. Clay ſaturated with the marine acid; marine embryon alum.

Species.

V. Clay combined with about one part and an half of ſilex, nearly one part of magneſia, and half a part of dephlogiſticated iron; mica.

VI. VII. VIII. IX. Clay combined with ſiliceous earth, magneſia, calcareous earth, iron, or a bitumen; ſlate, blue ſchiſtus, pyritous ſchiſtus, bituminous ſchiſtus, and argillaceous ſchiſtus.

X. Clay combined with a little ſilex, magneſia, and calcareous earth, with a quantity of iron calx, nearly equal in weight to the clay; horn-ſtone, or *horn-blende.*

XI. Clay combined with a quantity of ſilex equal to four times its own weight, with half its weight of calcareous earth, and ſomewhat more than its weight of iron; toadſtone.

XII. Clay united to from twice to eight times its own weight of ſilex, half its weight of lime, and once or twice its weight of water; zeolite.

XIII. Clay united with four times its own weight of ſilex, and one third of iron; pitch-ſtone, lava.

XIV. Clay mixed with a diſcernible portion of red iron calx, and ſometimes with ſteatites; red chalk.

To theſe Mr Kirwan adds ſix compound ſpecies in which the argillaceous genus predominates.

SILICEOUS GENUS.

This genus in Mr Kirwan's ſyſtem, comprehends twenty-ſix ſpecies.

Species.

I. Siliceous earth nearly pure; quartz, cryſtal ſand.

II. Siliceous earth, with one-fourth clay, and one-fortieth calcareous-earth; ſilex, gun-flint. See *Weigleb. Act. nat. Curioſ. t.* 6. *p.* 408.

III. Siliceous earth, with from one-fourth to one-third clay, and from one-twelfth to one-fifteenth calcareous earth; petroſilex.

IV. Siliceous earth, with one-third clay, and one-ſixth or one-ſeventh iron calx; jaſper.

V. Fine ſiliceous earth, mixed in various proportions with iron and other earths; agate, opal, chalcedony, onyx, carnelian, and ſardonyx. Precious ſtones of the ſecond order.

VI. Siliceous earth, with from an equal quantity, to nearly three times its own weight of clay, from a ſixth part to an equal quantity of calcareous earth, and from one-eighteenth to an equal quantity of iron; ruby, topaz, hyacinth, emerald, ſapphire. Precious ſtones of the firſt order.

VII. Amethyſt. The principles of its compoſition are not yet known.

VIII. Siliceous earth, with one fifty-fifth of calcareous earth, a ſmaller quantity of magneſia,

ſia, and a very ſmall quantity of iron, copper, and ſparry acid; chryſophraſe.

IX. Siliceous earth, with blue fluor ſpar, and a little gypſum; *lapis lazuli.* M. Margraf found in it chalk, gypſum, ſilex, and iron. M. Rinman obſerved it to contain a portion of the ſparry acid.

X. Jade. M. Kirwan conjectures it to conſiſt of ſilex, magneſia, and iron.

XI. Siliceous earth, with clay, ponderous earth, and magneſia; feldt-ſpar, petuntze, and Labradore ſtone. 100 parts of feldt-ſpar contain 67 parts of ſilex, 14 of clay, 11 of ponderous earth, and 8 of magneſia.

XII. Siliceous zeolite. This ſubſtance is found at Mæſſiberg. It differs from the true zeolite in giving fire with ſteel, which the other does not; and this property is a proof that ſilex is one of its principles.

XIII. Siliceous earth, with clay equal to more than a third part of its weight, and one-ninth of chalk, with no iron; white garnet of Mount Veſuvius. 100 parts of it contain, according to Bergman, 55 of ſilex, 39 of clay, and 6 of chalk.

XIV. Siliceous earth with clay, chalk, and one-tenth of iron; garnet. Bergman ſays that 100 parts of this ſtone contain 48 of ſilex, 30 of clay, 12 of calcareous earth, and 10 of iron.

Species.

XV. Siliceous earth, with a good deal of clay, nearly one-tenth of chalk, and a little iron and magneſia; ſchörl.

XVI. Bar ſchorl, German *ſtangen ſhoerl;* found by M. Fichtel on the Carpathian mountains. It is found among lime-ſtone, is of a priſmatic form, and gives a ſlight effervеſcence with acids. M. Bindheim obtained from 100 parts of this ſchorl, 61 of ſilex, 21 of chalk, 6 of clay, 5 of magneſia, 1 of iron, and 3 of water.

XVII. Tourmalin. The following are, according to Bergman, the proportions of the principles of the tourmalins of Tyrol, Ceylon, and Brazil.

	Clay.	Sil.	Cal.E.	Iron.	
Tourmalin of Tyrol	42	40	12	6	100dth parts.
——— of Ceylon	39	37	15	9	
——— of Brazil	50	34	11	5	

XVIII. Baſaltes; trapp. 100 parts contain, according to Bergman, 52 of ſiliceous earth, 15 of clay, 8 of calcareous earth, 2 of magneſia, and 15 of iron.

XIX. Rowly rag. A grey, granulated ſtone, which heat renders magnetic and melts, and which in the air acquires an ochreous cruſt. 100 parts of it, according to Withering, contain 47.5 of ſiliceous earth, 32.5 of clay, and 20 of iron.

XX. Silex, clay, iron, and calchreous earth, melted together by volcanic fire.

XXI.

Species.

1. Cellular lavas, improperly called pumice-ſtones. Theſe have been very imperfectly melted. Bergman found them to contain from $\frac{45}{100}$ to $\frac{50}{100}$ of ſilex, from $\frac{15}{100}$ to $\frac{20}{100}$ of iron, $\frac{4}{100}$ or $\frac{5}{100}$ of pure calcareous earth; and the reſt of the compoſition, clay.
2. Compact lavas. Theſe have undergone a ſecond fuſion, and have therefore but few cavities. They ſound when ſtruck.
3. Vitreous lavas, or lava entirely melted into black, green, blue, &c. glaſs. M. Sauſſure, by melting together, more or leſs thoroughly, certain quantities of horn-rock, marl, and ſchiſtus, has produced imitations of theſe lavas. (*Voyage dans les Alpes, p.* 127).

XXI. Siliceous earth, united with about a tenth part of magneſia, and a very ſmall portion of calcareous earth; pumice ſtone.

XXII. Siliceous earth, with leſs than its own weight of magneſia and iron; martial magneſian ſpar. Piſolite found at Sainte Maire, by M. Maret.

XXIII. Siliceous earth, with one third its own weight of aërated calcareous earth; Turkey ſtone. Oil hardens it.

XXIV. Siliceous earth, mixed with a little iron and calcareous earth. Rag-ſtone.

XXV. Quartz conſolidated with leſs than its own weight of calcareous earth or clay, and a little iron; grit reducible to ſand by pounding Var. I. Grit with a calcareous cement; of Fontainebleau: it efferveſces with acids. II.

With

Species

With an argillaceous cement. This variety does not efferveſce. It is uſed for building, for whet-ſtones, and for filtering water, &c.

XXVI. Siliceous earth conſolidated with ſemi-phlogiſticated calx of iron; brown or black ſcintillating ſtone, which becomes red and exfoliates in the air. Semi-phlogiſticated iron agglutinates earths; but iron, when very much calcined, poſſeſſes not the ſame agglutinative power. This fact has been demonſtrated by Meſſrs Edward King and Gadd.

To theſe twenty-ſix ſpecies of the ſiliceous genus, Mr. Kirwan annexes ſix other ſpecies in which that earth predominates. The varieties which he includes under theſe ſpecies, are compounds frequently found in mountains of ancient formation. The Engliſh chemiſt draws this ſupplement to the ſiliceous genus from M. Sauſſure's obſervations on the Alps. Among theſe varieties are, the ſeveral kinds of granite, pudding-ſtones, granitelloes, granitines, porphyry, gneis, variolite, &c *.

CHAP.

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* Since the publication of the fourth edition of M. Fourcroy's work, Mr Kirwan has publiſhed a new edition of his Elements of Mineralogy, in which his ſyſtem is greatly altered and enlarged.

In this edition he enumerates nine ſimple earths, the calcareous, the barytic, the magneſian, argill, the ſiliceous, the Scottiſh, the jargonic, the adamantine; but not without intimating a ſuſpicion, that the four laſt may be modifications of ſome of the five firſt.

In addition to the *chemical characters* which he before employed alone in his arrangement of ſtones, he has now adopted from the illuſtrious Werner, the uſe alſo of the *external phyſical characters*, indicated by that naturaliſt.

The *external characters* which Kirwan here employs, are, *colour, ſhape, luſtre, tranſparency, texture, coheſion, denſity, adheſion* to the tongue or fingers, and general *feel, colour of a ſtreak, abſorption or diffuſion* in water, *ſmell*, and *taſte*.

The *internal characters, are, relation to acids, changes operated in a low heat, fuſibility and* other changes in higher degrees of heat, *phoſphoreſcence, magnetiſm, electricity*, and the reſults of a juſt analyſis.

He gives very ample tables of the fuſibility of the ſimple earths, mixed in various proportions, in heats not exceeding 166°. of Wedgewood's pyrometer.

His primary genera conſiſt of earths and ſtones having an HOMOGENEOUS aſpect.

The ſpecies of the *calcareous genus*, are now augmented to the number of *thirteen*, and are all conſiderably altered in the deſcriptions of them, and in their arrangement in the table.

The ſpecies of the *barytic genus* are now reduced to *three*; barolite or aërated barytes; barytes combined with the vitriolic acid; and the liver-ſtone, or *lapis hepaticus*.

The ſpecies of the *magneſian*, or *muriatic genus*, are now increaſed to *twenty*.

The *argillaceous genus* is divided into *two claſſes*; *the firſt* comprehending argillaceous earths liable to moulder in water, and ſubdivided, not into ſpecies, but into *ſix tribes*; *the ſecond* containing argillaceous ſtones not liable to moulder in water, and ſubdivided into *ſeventeen ſpecies*.

The ſpecies of the *ſiliceous genus* are now augmented to *forty-four*.

The *ſtrontian* or *Scottiſh genus* conſiſts of but *a ſingle* ſpecies.

The *jargonic genus* has no ſpecies, ſave only the jargon of Ceylon.

The *Sydneian* is not more diverſified than the two laſt foregoing *genera*.

The *adamantine genus* has but the ſingle ſpecies of adamantine ſpar, diverſified into three varieties.

From the diſcrimination and hiſtory of theſe homogeneous earths and ſtones; Mr Kirwan next proceeds to examine AGGREGATED *ſtones*; which he defines to be "ſtones viſibly involving two or more heterogenous ſubſtances, either adhering together, or inheſing one in the "other." Of this character, he enumerates and deſcribes granite, ſienite, granatine, granitell, granilite, gneiſs, ſhiſtoſe mica; porphyry, jaſper porphyry, hornſtone porphyry, pitchſtone porphyry, obſidian porphyry, horn porphyry, petunſe, petunſe porphyry, clay porphyry, hornblende porphyry, trap porphyry, wacken porphyry, mullen porphyry, kragg porphyry, argillitic porphyry, novaculite porphyry, pitſtone porphyry, ſerpentine porphyry, granite porphyry, ſandſtone porphyry, amygdaloid, pudding ſtone; calcareous ſandſtone, argillaceous ſandſtones, ſiliceous ſandſtones, ferruginous ſandſtones, rubleſtone, brecias.

After theſe follow the DERIVATIVES, which are defined as "ſeeming "to participate of the nature of two or perhaps more heterogeneous "foſſils, without, however, any viſible ſeparation of one from the other."

In three APPENDICES, Mr Kirwan, examines, 1. diamond, and 2. volcanic products; and 3. gives an account of the chemical analyſis of earths and ſtones.

The ſecond volume of this valuable work, in which the author promiſes to treat of ſaline, inflammable, and metallic ſuſtances, is impatiently expected by the public—*H.*

CHAP. IV.

Of the Chemical Analyſis of Earths and Stones.

THOUGH, within theſe few years, the chemical analyſis of earths and ſtones has been much more induſtriouſly proſecuted than at any former period, yet ſtill it muſt be confeſſed, that our knowledge of their component principles is far from being ſufficiently extenſive or accurate, to be aſſumed as the foundation of a methodical arrangement of them. Hence the diverſity of the chemical claſſifications of theſe ſubſtances which have been hitherto offered to the public; and for this reaſon have we been induced to give an account of the different methods ſucceſſively propoſed by three celebrated chemiſts in the courſe of a very ſhort period of time.

The chief advantage which has been gained from the various reſearches of late made into the nature and component principles of earths and ſtones, is the diſcovery of proper means for diſtinguiſhing theſe. The method of analyſing theſe ſubſtances is not a little complex; and I mean to give only a general account of it in this chapter. In fact, as the ſtudent of chemiſtry, who has read only the foregoing part of this work, though acquainted in ſome degree with the phenomena of fire, air, and water, muſt be entirely ignorant of the properties of ſaline bodies, which are ſo efficaciouſly employed in ſeparating and examining the conſtituent principles of earths and ſtones; if we were here to ſpeak of the uſe of ſolvents in analyſing theſe matters, we ſhould both deviate from that order and regularity which are neceſſary in laying down the elements of phyſical ſcience, and likewiſe run the riſk of becoming unintelligible: I ſhall therefore reſerve a minute and particular account of the chemical decompoſition of earths and ſtones by acids and alkalis to a different part of the work *, explaining here nothing but its general principles.

When we wiſh to diſcover the chemical properties of a ſtone or an earth, we muſt begin with a careful examination of its phyſical properties, its form, hardneſs, gravity, colour, &c. The extraneous ſubſtances, of which there is always a greater or a leſs quantity mixed with ſuch bodies, muſt next be ſeparated from it, ſo as that it may be purified from all mixture, by picking, waſhing, &c. A ſtone ſhould be reduced to powder, or, if the expreſſion may be allowed to the ſtate of earth, before we attempt to examine its principles. The firſt trial that is made is generally with fire. A few ounces are expoſed in a well-baked crucible of clay or porcelain, to the heat of a ſtrong furnace, ſuch as Macquer's; that of a potter's or a glaſsmaker's is ſtill better for the purpoſe. It is to be obſerved of the crucibles uſed in this operation, that the argillaceous earth of which they are chiefly compoſed has

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* See the treatiſe *on the Analyſis of Waters*, at the end of this work. —F.

has often a conſiderable ſhare in producing the alteration which the ſtony ſubſtance ſeems to ſuffer from heat: but we have no way of avoiding this inconvenience; and indeed it becomes of little conſequence in a comparative analyſis of a great number of ſtones. Of late years, the uſe of the blow-pipe for treating mineral matters with fire, has been introduced; and in the chemical examination of an earth or a ſtone, this inſtrument may be employed together with the above deſcribed means for decompoſition. Thoſe ſubſtances are expoſed to the fire, either alone or ſeveral of them mixed together, or with a mixture of ſome ſaline matters to be afterwards deſcribed[*]. Laſtly, they may be likewiſe treated with a machine for pouring vital air on coals, of which I have given a deſcription in my *Memoirs de Chimie*, and which produces a heat that for intenſity may be compared to the focus of a glaſs lens, ſuch as that of the academy. Theſe operations produce either a fuſion more or leſs perfect, or ſome change of colour, conſiſtency, form, &c. which is to be carefully deſcribed. The proceſs muſt be farther carried on, by putting the ſtony matter into an earthen retort, fitted up with a receiver and a pneumato-chemical apparatus[†], in order to collect whatever water and aëriform fluids may be diſengaged. Matters which afford theſe products are properly ſalino-terrene ſubſtances, though they be conſidered as ſtones by naturaliſts;

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[*] See Bergman's paper on the blow-pipe, with Mongez's notes *Manuel de Mineralogiſte*; or Cullen's Engliſh tranſlation of Bergman.—F.—H.

[†] See a deſcription of this apparatus under the article *Gas* of the Chemical Dictionary, or in M. Sigaud de la Fond's work on the different kinds of air.—F.

yet, as they are often found mixed with genuine earths, it is therefore proper to mention here the general mode of examining them. The action of fire ſhows whether a ſtone be ſiliceous, aluminous, or mixed. But as moſt ſtones are of the latter kind, and many of them conſiſt of ſeveral, ſome even of five or ſix, different ſubſtances united in various proportions, other proceſſes are likewiſe to be employed for determining the principles of their compoſition. Theſe conſiſt in treating them with ſeveral acid and alkaline ſolvents, the ſucceſſive application of which ſeparates all the principles of which they conſiſt.

The action of air, and of water in vapour, may likewiſe contribute to make us underſtand the nature and conſtituent parts of earthy and ſtony matters. Some of them ſuffer no alteration from theſe agents; others are divided, and gradually aſſume a new form, colour, and conſiſtency. Theſe phenomena belong chiefly to ſtones of a very compound nature, and containing much iron. Laſtly, lixiviation with cold and warm water, ſhows whether they contain ſaline matters, however difficult it may be found to bring theſe to ſolution.

Such are the means by the uſe of which modern chemiſts have been able to determine the nature and the component principles of ſo great a number of earths and ſtones. I have here given but a very ſhort and general account of them. In the hiſtory of ſaline matters, we ſhall give all thoſe particulars concerning them which cannot be conveniently or advantageouſly introduced here.

SECTION II.

CHAP. I.

Of Saline Subſtances in general; their Characteriſtics, Nature, and the Method of arranging them.

SALINE ſubſtances, of which there are a very conſiderable number, poſſeſs peculiar properties by which they are diſtinguiſhed from thoſe which we have hitherto been examining. The properties which have been employed by *chemiſts* as characteriſtics of ſaline matters, are ſuch as leave their real nature ſomewhat uncertain: being common to many other bodies beſide ſalts, they extend this claſs of ſubſtances far beyond its juſt limits. Taſte and ſolubility in water, which have been always given as characteriſtics of ſaline ſubſtances, belong to many bodies which are not ſaline; as for inſtance, to all mucilages and animal matters. Theſe two properties again exiſt in a very low and imperfect degree in ſeveral ſaline ſubſtances. *Naturaliſts* have not been more accurate in their definitions of ſalts: the tranſparency and cryſtalline form which many naturaliſts have conſidered as peculiar to them, belong equally to many other matters, eſpecially earths, while ſome ſalts are quite deſtitute of them.

Macquer has, therefore, aſſerted, with great truth, that the true limits which divide ſaline matters from other claſſes of ſubſtances are not well known.

Yet as we *muſt* take *ſome* ſide, and form ſome determinate notions concerning the properties of theſe matters, we ſhall take a general view of them, before proceeding to the hiſtory of each particular ſalt.

We acknowledge as ſaline ſubſtances, all ſuch as poſſeſs the greater part of the four following properties: 1. A ſtrong tendency to combination, or affinity of compoſition: 2. A ſtronger or fainter taſte: 3. A greater or a leſs tendency to ſolution: 4. Abſolute incombuſtibility. Before proceeding to conſider each of theſe properties by itſelf, we muſt obſerve, that in proportion as a body contains more or fewer of them, and thoſe in a greater or leſs degree, it is more or leſs of a ſaline nature. From this, however, we muſt not conclude, that matters poſſeſſing theſe properties but in a very faint degree are not ſaline. Were we to admit ſuch a principle, we ſhould expoſe ourſelves to frequent errors; as it ſometimes happens that two ſalts, which in a ſolitary ſtate poſſeſſed theſe properties in a very low degree, afford ſtill fainter indications of them after being combined. In ſuch caſes recourſe muſt be had to chemical analyſis, which, by ſeparating the ſubſtances, will render their chemical properties more obſervable.

§ I. *Tendency to Combination conſidered as a Characteriſtic property of Salts.*

MOST ſalts have a tendency to combine with many different ſubſtances. Among ſalts we find the moſt active bodies in nature, capable of forming an infinite number of combinations, by entering into union with others. Chemiſts have, therefore, always made moſt uſe of ſaline matters; ſome of which they have honoured with the names of *ſolvents* and *menſtrua.* Yet this tendency to combination is far from being the ſame in all ſalts. Some of them poſſeſs it in ſo ſtrong a degree, that they corrode and deſtroy, or diſſolve whatever touches them, even vitrifiable and quartzoſe ſtones not reſiſting their attacks; ſuch is the power of many of thoſe pure ſalts that are known by the names of *acids* and *alkalis.* Others, though not poſſeſſed of ſuch a force of combination, unite readily with many bodies. Laſtly, there are ſome among them, whoſe tendency to combination is but very trifling, and ſcarce ſuperior to that of earthy matters. But the cauſe why, in theſe latter, the tendency to combination is ſo ſmall, is, their being in a great meaſure ſaturated, as is obſervable of moſt neutral ſalts. After this, we cannot well be ſurpriſed that ſalts are ſcarce ever found in a pure or ſolitary ſtate in the bowels of the earth.

§ II. *Taſte conſidered as a Characteriſtic of Salts.*

TASTE has been always regarded as ſo eſſential a property of ſaline ſubſtances, that many philoſophers have conſidered them as the only bodies in nature poſſeſſed of this property, and the principle of all taſte. Though this opinion be not demonſtratively certain, as there are many bodies, ſuch as metals, which have a diſcernible taſte, though not ſaline, while, again, ſeveral ſaline ſubſtances have ſcarce any taſte; yet it muſt be acknowledged, that moſt ſalts poſſeſs the property of taſte; and this property is therefore to be conſidered as one of their leading characteriſtics. The taſte of ſalts, like their other properties, is different in different ſpecies. In order to underſtand aright on what circumſtances it depends, and whence the cauſes of its varieties, we muſt firſt endeavour to diſtinguiſh what conſtitutes the peculiar nature of this property. By taſte, we uſually underſtand an impreſſion made on a certain organ which nature has given us for the purpoſe of diſtinguiſhing by it ſome material body, and from which we judge of that body as uſeful or noxious, and determine either to make uſe of it or reject it. It is therefore the action of the lapid body on the nerves of the tongue and palate of animals, which informs them that one ſubſtance may be of uſe, or another hurtful to them. But can this property of bodies affect only the nerves of the tongue? will it not act with equal force on the whole nervous ſyſtem? Thoſe who are acquainted with the phenomena of the animal œconomy, know that the action which conſtitutes taſte or ſapidity, muſt affect all the other nerves, and muſt always be proportioned to the ſenſibility of the ſubjects and the organs on which it operates. This idea of taſte naturally leads us to think, 1. That this quality of bodies will make ſcarcely any impreſſion on ſuch parts of the body as have but few nerves, or of which the nerves have but little ſenſibility, on account of their being covered; as on the ſkin where they are defended by the reticular membrane and the epidermis. 2. That this quality of bodies will act with the moſt energy on thoſe organs in which the nerves are largeſt, moſt numerous, and of a form the moſt proper for receiving an extenſive contact, and a violent emotion from ſalts; the epidermis being ſo thin as to leave the nerves almoſt naked. The ſuperior ſurface of the tongue, the roof of the mouth, and all the inner part of the mouth in general, are ſuſceptible of the ſenſation of taſte, from a vaſt number of bodies which make no ſuch impreſſion on the leſs delicate ſenſibility of the other parts of the ſkin. 3. That bodies which have no taſte and no power of affecting the ſkin, may notwithſtanding this, act upon organs which are more delicate, and have nerves of greater ſenſibility, ſuch as the ſtomach and the inteſtines.

Admitting theſe facts, we may diſtinguiſh taſtes and ſapid bodies into three claſſes, under which all the ſaline ſubſtances that we are to examine may be arranged. The firſt claſs comprehends ſuch ſalts as have the ſtrongeſt taſte, and affect the ſkin in the moſt ſenſible manner. The impreſſion of theſe ſalts is ſo powerful, that it occaſions a very lively ſenſation of pain; and where its action is continued for ſome time, it entirely deſtroys the organization and texture of the ſkin. This property is called *cauſticity*, and the ſalts which poſſeſs it are named *cauſtics*. The ſecond claſs conſiſts of ſalts which have a milder taſte, and affect only the nerves of the organs through which we receive that ſenſation: theſe are diſtinguiſhed from one another by names expreſſing the ſeveral impreſſions which they make on thoſe organs; ſuch as bitterneſs, aſtringency, acidity, acridity, urinous taſte, &c. To the third claſs we ſhall refer ſaline ſubſtances, the taſte of which is ſenſible only to the ſtomach and the inteſtines; but the number of theſe ſalts is very ſcanty.

Some obſervations are neceſſary on the mutual relations of theſe ſeveral claſſes of ſalts. It is firſt to be obſerved, that between thoſe which poſſeſs the peculiar properties of any of the three claſſes in the weakeſt, and thoſe which poſſeſs the ſame properties in the ſtrongeſt degree, there are many varieties; there are ſtronger and weaker cauſtics; ſome inſtantly deſtroy the texture of organized ſubſtances, others require a conſiderable time to produce that effect. The ſame fact may be obſerved of bitter, aſtringent, or urinous ſalts, as well as of thoſe which act only on the nerves of the ſtomach. Secondly, when we conſider theſe varieties of the ſeveral claſſes, we are naturally led to think, that all taſtes are but different degrees of the ſame property, from that of the ſtrongeſt cauſtic ſalt to that of the ſaline ſubſtance, whoſe action is ſcarce ſenſible to the nerves of the ſtomach. This obſervation implies, that all taſtes actually depend on the ſame cauſe, and participate of the ſame principle.

We cannot adopt an happier method of diſtinguiſhing the cauſe of taſte, than to conſider that taſte which is the ſtrongeſt of all, obſerve its phenomena, and attend to its action. Cauſticity muſt therefore be the ſubject of our conſideration: a property which has always attracted the curioſity of chemiſts. Lemery, obſerving that very hot bodies were uſually very cauſtic, and that all ſalts poſſeſſing the property of cauſticity have been ſtrongly heated before acquiring it, aſcribed this property to the particles of fire lodged in cauſtic bodies. M. Baumé has implicitly adopted Lemery's opinion. Meyer, an apothecary of Oſnaburgh, made a ſeries of reſearches into the nature of cauſtic ſalts, and formed a very plauſible theory, which was at firſt warmly embraced by a number of chemiſts, but is no longer mentioned with the reſpect which it once obtained. He attributed cauſticity to a principle which he conſidered as a compound of fire and a peculiar acid: this, in imitation of the ancient chemiſts, he named *cauſticum*, or *acidum pingue*. He traced it through its various combinations, as Stahl had done with phlogiſton. But his ſyſtem has the ſame defect with Stahl's; the exiſtence of his *cauſticum* has not been demonſtrated. Dr Black, by a ſeries of experiments on the ſame matters which Meyer examined, has levelled the ſevereſt blow again *his* theory; proving, by rigid demonſtration, that lime and alkalis, inſtead of deriving their cauſticity from a *fat acid* principle, become acid in conſequence of loſing a ſalt, to be afterwards mentioned under the name of the *Carbonic Acid*.

Macquer has undeniably been the moſt ſucceſsful inquirer into the cauſe of cauſticity. The doctrine which he lays down on that article in his Chemical Dictionary is ſo plain, and ſupported by ſuch concluſive facts, that we cannot refuſe aſſenting to his opinion. After obſerving that cauſtic bodies deſtroy and corrode our organs, by entering into combination with the principles of which they are compoſed, he remarks, that in proportion as this combination takes place, the cauſtic gradually loſes its ſtrength; and that it becomes abſolutely deſtitute of cauſticity, when it has diſſolved as much of the animal matter as its force and quantity are equal to. Thus the *lapis cauſticus*, or pure fixed alkali, gnaws and corrodes the ſkin when applied to it; but loſes its corroſive and ſolvent power when it ceaſes to act on that organ. This ſalt really acts by a chemical power, for it exerts its force even on the inſenſible ſkin of a carcaſe; as M. Poulletier has ſhown by accurate experiments, and on all animal ſubſtances in general. Cauſticity therefore depends on tendency to combination; and the ſenſations with which it affects our organs are occaſioned by the combination of the cauſtic with the matter of which the organs are compoſed. In the ſame manner a cauſtic loſes its virtue in the laboratory, by combining with any ſubſtance with which it has a ſtrong affinity; and in a word, the cauſticity of a body is always in the proportion of its tendency to combination. That ſalt which has the fainteſt taſte is already ſaturated with ſome ſubſtance; and by ſeparating it from that ſubſtance, we cauſe it to regain a taſte, ſtronger or weaker, according as the ſeparation is more or leſs complete. The whole hiſtory of ſaline matters concurs to ſupport this opinion, as will appear in what follows.

§ III. *Solubility conſidered as a Characteriſtic of Salts.*

Solubility in water has been given by all chemiſts as one of the moſt eminent characteriſtics of ſalts; yet this property, like taſte and tendency to combination, is ſubject to varieties. Some ſalts poſſeſs it in ſuch a degree, that without very long and refined proceſſes, it is impoſſible to ſeparate them entirely from water. Others are not ſo extremely ſoluble, and the degrees of their ſolubility may be preciſely aſcertained; as, for inſtance, moſt neutral ſalts. Laſtly, there are ſome ſaline ſubſtances, whoſe tendency to ſolution is ſo faint and indiſtinct, that they ſeem to differ more in nature from the other claſſes of ſalts than from earths and ſtones; and all ſalts of this character have been by moſt naturaliſts conſidered as earths and ſtones. It is indeed extremely difficult to fix the preciſe limits between theſe two claſſes of mineral bodies; and chemiſts have not as yet agreed in determining them. Mr Kirwan, in his mineralogy, ſeems to have adopted Bergman's opinion; who thinks that all ſubſtances are to be conſidered as earths, which require more than a thouſand times their own quantity of water to maintain them in a ſtate of ſolution, while all ſuch as are ſoluble in a ſmaller proportion of water, ſhould be diſtinguiſhed as ſalts. Were this propoſition generally received among chemiſts, as I think it well deſerves to be, that diverſity of opinions and terms which has hitherto prevailed on this point might be avoided; and they have a direct tendency to render the ſcience more obſcure and perplexing to beginners.

The relation which I have taken notice of, as ſubſiſting between the taſte and the ſolubility of ſalts, is preciſely the ſame with that which ſubſiſts between taſte and tendency to combination. The cauſe of theſe relations may be eaſily underſtood by obſerving, that ſolution in water is a real chemical union of a ſalt with a fluid, and muſt therefore depend on the ſame laws with taſte and tendency to combination. In fact, the more taſte and ſolvent force a ſalt has, the more readily does it diſſolve in water. This law holds invariably with regard to all ſaline matters, and even depends on their nature and eſſential properties.

§ IV. *Incombuſtibility conſidered as a Characteriſtic of Salts.*

It is more difficult to form a determinate idea of this fourth than of the three preceding characteriſtics of ſaline matters. No chemiſt has as yet conſidered theſe ſubſtances under this point of view. A number have even thought, that ſome ſalts, and among others nitre, are actually combuſtible.

In order to ſee clearly that this is a miſtake, and that all mineral ſaline ſubſtances are abſolutely incombuſtible, the ſtudent of chemiſtry muſt have a much fuller knowledge of the properties of thoſe ſubſtances, than he can have acquired from peruſing the foregoing part of this work. However, as we think this one of the moſt eſſential and important characteriſtics of ſalts, we ſhall here give a ſhort view of the doctrine which we are induced to advance on this head, and which will be fully illuſtrated and inconvertibly eſtabliſhed, in our particular examinations of ſaline ſubſtances.

It appears from M. Lavoiſier's fine experiments, that many combuſtible matters form by their combuſtion, peculiar acids. Combuſtion, as above explained, is nothing but the combination of the baſe of vital air, or the oxigenous principle with combuſtible bodies. Every body which has been completely burnt, that is, which has been ſaturated with the oxigenous principle, returns into the claſs of incombuſtibles; or what is juſt the ſame, its tendency to combine with the oxigenous principle is ſatisfied, and it cannot unite with a new quantity of oxigene, or abſorb any more of it. This being admitted, it plainly follows, that, as a number of ſalts are reſidues of various combuſtible bodies, and even an entire claſs of ſaline ſubſtances are found to have oxigene for one of their principles, and exhibit the characteriſtics of ſubſtances which have been expoſed to combuſtion; theſe cannot be any longer ſuſceptible of combuſtion. A numerous train of facts, which ſhall be hereafter related, concur to juſtify theſe aſſertions: they prove ſalts to be compound bodies, moſt of them formed by the union of certain combuſtible bodies with the oxigenous principle. From this it is eaſy to underſtand that incombuſtibility deſerves to be regarded as one of the moſt certain and invariable characteriſtics of ſaline matters. We hope that this will be completely demonſtrated of the claſs of acid ſalts, when we come to enter particularly into the hiſtory of thoſe ſubſtances.

Yet there is one claſs of ſalts which, though evidently compound bodies, are not known to contain any portion of the oxigenous principle: all the alkalis are of this claſs. But theſe are either compounds of incombuſtible bodies, or if ſome combuſtible matter enter into their compoſition, as we ſhall have occaſion to obſerve of ammoniac or volatile alkali, it is united with ſome ſubſtance evidently incombuſtible, which hinders the combuſtibility of the other matter from being obſerved.

§ V. *Of the general Nature and Compoſition of Saline Matters.*

Stahl, after ſtudying the nature of ſalts with much attention, was perſuaded that they were generally formed of earth and water. He collected all that chemical reſearches could ſupply to ſupport and illuſtrate his theory. But ſince that illuſtrious æra of chemical ſcience has been ſucceeded by one ſtill more illuſtrious, for both the multiplicity of the reſearches proſecuted, and the importance of the diſcoveries which theſe have produced; Stahl's theory, which is very perſpicuouſly explained in the works of Macquer, is no longer ſufficient to explain the nature and compoſition of ſalts. We are no longer content with thoſe remote analogies which forced the moſt diſcordant facts into an unnatural union, and bewildered the underſtanding by exhibiting to it illuſive lights. Philoſophers now chooſe rather to confeſs their ignorance, than to advance ill-founded theories, which may ſooner or later be refuted by experiments.

Although the chemical nature of ſalts be not yet entirely known, and facts allow us not to agree with ſome of the moſt eminent philoſophers, in acknowledging one ſaline principle as the baſe and element of all ſalts; yet the component principles of this ſingular and numerous claſs of ſubſtances, are ſomewhat better known now than formerly. We know that moſt of them contain a very conſiderable quantity of the oxigenous principle; which principle is fixed in ſome combuſtible matter. This has fully been ſhown to be the compoſi-

tion

tion of a number of acids; and we have the ſtrongeſt reaſon from analogy to conclude, that moſt other ſalts of that claſs have the ſame character. Water, though not one of the immediate principles of ſalts, is often found united to them, and has a ſtrong affinity with them. As to the matter of fire conſidered as phlogiſton, which ſome of the moſt eminent chemiſts have admitted as a component principle in ſalts, the nature and exiſtence of that matter are too uncertain to admit of our adopting any determinate opinion in reſpect to it. The caſe is not the ſame with the caloric principle; it ſeems evidently to conſtitute one of their component principles; in ſome however, it exiſts in a much ſmaller proportion than in the reſt, which appear in general to owe to it their fludity, fuſibility, and volatility. The exiſtence of earth in any conſiderable number of ſalts has never been experimentally demonſtrated. We know only that all the ſaline bodies which nature exhibits, are mixed with a larger or a ſmaller quantity of various earthy ſubſtances. But theſe, properly ſpeaking, do not belong to them; they form no part of their compoſition, and may be ſaid to be only acceſſories. The only ſubſtances at preſent acknowledged as general principles of ſaline matters, are ſeveral combuſtible bodies, the oxigenous principle, a few incombuſtible matters, and the caloric principle. It is well known that moſt acids are reſidues of burnt bodies, and contain oxigene and combuſtible matter combined together in various proportions. Whatever more has been advanced in treatiſes on chemiſtry concerning the nature of ſalts, is nothing but ingenious or ridiculous hypotheſis, unſupported by any ſolid baſis of facts.

§ VI. *Of the Diviſion and Arrangement of Mineral Saline Matters.*

The ſalts belonging to the mineral kingdom are very numerous. A number of them are products of nature, formed by the action of fire, water, and air, and by the diſſolution of organic matters. But moſt of thoſe which are employed in chemiſtry owe their formation to art, or at leaſt have not hitherto been found among the products of nature. In order to give a methodical view of the hiſtory of theſe ſubſtances, we ſhall divide them in the ſame manner as ſtones, into orders, genera, and ſpecies. All ſaline matters may be arranged under two orders.

The firſt contains thoſe ſaline ſubſtances which have been named *ſimple*, and which we ſhall diſtinguiſh by the name *primary ſalts*, becauſe they ſerve as principles to thoſe of the ſecond order.

The ſecond conſiſts of the ſecondary, compound, or neutral ſalts. Theſe are formed by the combination of two or more of the former order, and are of conſequence much leſs ſimple than they.

Each of theſe orders ſhall be divided into ſeveral genera, and theſe again into ſpecies.

Nine genera, and eighty-ſix ſpecies of ſimple and compound ſalts together, are at preſent known to exiſt in the mineral kingdom; and theſe we ſhall ſucceſſively examine *.

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* There are three ſalino-terrene ſubſtances, three alkalis, and ten mineral acids. Theſe laſt, united with aluminous earth, with the three ſalino-terrene baſes, and with the three alkalis, compoſe 70 compound or neutral ſalts.—F.

C H A P.

CHAP. II.

Of the three Salino-Terrene Subſtances[*].

ORDER I. SIMPLE *or* PRIMARY SALTS.

WE give the name of *ſimple* or *primary ſalts* to thoſe matters which were formerly known by the name of *ſimple ſalts*, and are ſtill ſo called by ſome chemiſts. As it has been ſhown, by fair experiments, that moſt of them are really compounds, therefore the title of ſimple ſalts cannot with any propriety be applied to them, except when they are compared with the ſalts of the ſecond order. The name of *primary ſalt*, ſeems the moſt ſuitable for diſtinguiſhing them, becauſe they form by combination thoſe neutral or compound ſalts which we call *ſecondary*. We ſhall divide this order into three genera, ſalino-terrene ſubſtances, alkalis, and acids. The examination of the firſt will occupy this chapter; in the two following we ſhall give the hiſtory of alkalis and acids.

Genus

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[*] The title of this chapter is the general denomination of the firſt genus of the firſt order of ſimple or primary ſaline matters.—F.

Genus I. *Salino-Terrene Subſtances.*

By this name we denote three ſubſtances which have been hitherto regarded as earthy matters, but whoſe properties plainly ſhow them to be more properly ſaline *. As theſe ſubſtances poſſeſs the diſtinguiſhing properties of ſalts, in conjunction with the characteriſtics of earthy matters, yet, diſplaying the latter in a leſs eminent degree; we therefore rank them before the ſalts, uſing them as a link of connection between ſalts and earths: They differ alſo from earths as having a ſtronger tendency than theſe to combination, as will appear from an examination of their properties.

It is proper to obſerve, that in our examination of theſe ſalino-terrene matters, as well as in our account of the primary ſalts, we ſuppoſe them pure and ſolitary, though they be never found ſo in nature; and we avoid mentioning the methods by which they are obtained, from a deſire not to break through that elementary order which we have determined to follow through the courſe of the work. When we come, in the hiſtory of neutral ſalts, to give an account of their decompoſition, we ſhall then have occaſion to deſcribe the methods by which chemiſtry ſeparates thoſe ſubſtances, as well as the ſimple or primary ſalts, ſo as to afford them pure.

This firſt genus contains three ſpecies of ſalino-terrene bodies.

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* We have already given ſome account of them in lithology; but then only as making a part of natural hiſtory.—F.

Species I. *Barytes.*

THE firſt name of this ſubſtance was *ponderous earth*; given it by the Swediſh chemiſts Gahn and Scheele, who diſcovered it in ponderous ſpar: Bergman and Mr Kirwan have already given it the Latin name *barytes*. Its ſpecific gravity, according to Mr Kirwan, is ſomething more than 4,000. Nature no where affords this earth in a pure but always in a combined ſtate. It was firſt diſcovered and diſtinguiſhed as a peculiar earth by the chemiſts above-mentioned. Meſſrs Margraff and Monnet had obſerved it, but confounded it with abſorbent or calcareous earth. Yet the laſt of theſe chemiſts had obſerved it to poſſeſs ſome peculiar properties, and ſuſpected it to be an earth different in its nature from lime. Its properties, in a pure ſolitary ſtate have not as yet been very accurately examined; its combinations have been more ſtudied; and what moſt eminently diſtinguiſhes it from other analogous ſubſtances, is, its very ſingular affinities, and the ſalts which it forms by combination with acids.

Pure barytes, obtained by means which ſhall be afterwards deſcribed, appears under a pulverulent form, very fine and white. I have never found it to affect the tongue with any diſcernible taſte.

It is not yet known whether this ſubſtance be liable to alteration from light.

The ordinary fire of our furnaces does not reduce it to fuſion: But if heated in a clay crucible, it communicates a blue or greeniſh colour to the crucible, and aſſumes itſelf a ſlight tinge of the ſame. This phenomenon ſeems to ariſe from its power of re-action on clay. M. D'Arcet ſays that it melts when expoſed to a very violent heat in a clay or iron crucible *.

When expoſed to the air, it acquires an acceſſion of weight, and combines, though very ſlowly, with the carbonic acid contained in the atmoſphere: the effects of vital air upon it are unknown. We are equally ignorant of the manner in which the oxigenous and the azotic principles, act upon this ſaline earth. Azote is perhaps one of its conſtituent principles.

Its diſſolves in water, but not without difficulty; for 900 parts of that fluid are requiſite to diſſolve one of barytes. Water thus ſaturated gives a pale green colour to the tincture of violets †, and ſtill more readily to that of mallows or raddiſhes. This ſolution, when expoſed to the air, is covered with a thin pellicle; and if it be ſtripped of this, a new one is produced. This phenomenon is owing to the carbonic acid in the atmoſphere: the ſame thing happens to lime-water, though in a leſs eminent degree. The ſolution, when evaporated in cloſe veſſels, leaves a reſidue of barytes; and the weight of the reſidue affords a proof of the ſolubility of that ſubſtance. It is almoſt unneceſſary to obſerve, that in

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* This is confirmed by the experiments of M. Lavoiſier, who fuſed barytes in a few ſeconds, with a flame fed with oxigenous gas. But this barytes appears to have been in ſome degree impure.—H.

† By tincture of violets, we mean a ſolution of the colouring part of violet flowers in water. This tincture when newly made is preferable to the ſyrup of violets, as being much eaſier affected. But the ſyrup may be employed in all inſtances in which the ſaline matters under examination act with a determinate energy; and we ſhall therefore often mention it inſtead of the tincture.—F.

in this, as in all other proceſſes of the ſame nature, diſtilled water is to be uſed.

Barytes acts but very feebly, either in the humid or the dry way, on ſiliceous and aluminous earth *. Yet it facilitates the fuſion of thoſe earths, and aſſumes a blue or greeniſh colour when heated with the latter of them. Barytes is leſs copious in nature than either of the other two ſalino-terrene ſubſtances; but it is probably more copious than it is thought to be. Formery, it was not known to exiſt in any body but barytic ſulfate or ponderous ſpar; it was ſome time ſince found in England, combined with the carbonic acid, and cryſtalliſed like a tranſparent ſpar. That ſalt will be afterwards deſcribed. Some modern chemiſts think it to be a metallic calx or oxide. Its weight, that of the compounds into which it enters, and the precipitate which it affords, when a ſolution of it with an acid is mixed with an alkaline pruſſiates, made Bergman long ſuſpect it to be of this nature. We are told, that M. Gahn, a pupil of that celebrated chemiſt, has actually obtained barytes under a metallic form; but this fact needs confirmation. Its nature therefore is ſtill unknown; becauſe we have never yet been able to ſepa-

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* We muſt here obſerve, that in order to give a regular account of the reciprocal action of bodies on each other, no combination of any two bodies is mentioned till after thoſe two have been deſcribed. Thus in the hiſtory of barytes, I have mentioned only the manner in which it is affected by light, by the caloric, the oxigenous, and the azotic principles, by water, and by ſiliceous and aluminous earth, becauſe none but theſe have as yet been deſcribed. As we advance in the hiſtory of natural ſubſtances, we ſhall learn all the combinations of which it is ſuſceptible. Thus we ſhall both preſerve our order inviolate, and communicate all the neceſſary information concerning the matters of which we treat.—F.

rate its principles, or imitate its compoſition. I ſuſpect, as I have already hinted, that the azotic principle, or the baſe of gas azote, is one of its component parts.

Pure barytes is not applied to any uſe; ſolutions of it in water and in acids are uſed as re-agents, as we ſhall elſewhere have occaſion to obſerve.

Species II. *Magneſia.*

THAT magneſia which is obtained from Epſom ſalt, or ſulfate of magneſia, and which is likewiſe found in mother water of nitre, and in a great many ſtones, &c. is no where in nature to be met with in a ſtate of purity, but always combined with acids. Dr Black is the firſt chemiſt who has accurately determined the diſtinction between it and lime.

This ſubſtance, which is obtained by methods to be afterwards deſcribed, appears under the form of a very fine white powder, reſembling meal both in appearance and to the touch. Its gravity, according to Kirwan, is about 2.33. It has no taſte ſenſible to the tongue; but it affects the ſtomach as a gentle purgative. It communicates a pale green to the tincture of violets and mallows, and cauſes turnſol to aſſume a blue colour. The manner in which light affects magneſia is not well known: it cannot be very powerfully.

According to the experiments of M. D'Arcet, this ſubſtance does not melt when expoſed to a ſtrong heat. Macquer too obſerved, that it remained unaltered in the focus of the burning lens of the garden *De l'Infante.* M. Morveau heated magneſia for two hours in the ſtrongeſt fire that can be procured in Macquer's furnace, with the ſame effect. M. Butini, a citizen of Geneva, who has publiſhed ſome valuable experiments on magneſia, has obſerved, that violent ignition contracts and condenſes magneſia in ſuch a manner as to render it capable of attacking and coroding an iron ſurface. We are informed that a ſmall cube formed of a paſte of magneſia and water, and expoſed to the focus of Parker's lens, was ſuddenly contracted in all its dimenſions. This property ſeems to indicate a relation between magneſia and aluminous earth; which two ſubſtances are often found together in nature, as was obſerved in the hiſtory of ſteatites, aſbeſtos, and ſerpentines, &c.

Magneſia, though heated in a retort, loſes not the portion of water which it contains: but when ſubjected to this proceſs, it acquires a very diſcernible phoſphoric quality, as has been obſerved by M. Tingry, apothecary at Geneva. It ſuffers no alteration from air, till after being long expoſed to it. M, Butini kept ten grains of calcined magneſia in a porcelain ſaucer covered with paper, in a dry room, for near two years; the only change which it ſuffered was by gaining one-eighth of a grain of additional weight. It appears that this ſubſtance combines ſlowly with the carbonic acid diffuſed through the atmoſphere.

It diſſolves in water but imperfectly and with great difficulty. Four ounces and two drams of pure water after ſtanding three months in a bottle, with a dram of calcined magneſia, and being boiled together with that ſubſtance, afforded M. Butini, by evaporation, a reſidue which he eſtimated at one-fourth of of a grain.

Mr Kirwan ſays, that 7900 times its own weight of water is neceſſary to diſſolve it in the ordinary temperature of the atmoſphere; that is to ſay, at about 60° of Fahrenheit's thermometer. Notwithſtanding this averſion to ſolution, magneſia forms a kind of paſte with water; that paſte indeed is not ductile, but brittle; and the water is readily ſeparated from it by the action of fire, or even of the dry atmoſphere. A ſolution of magneſia has no ſenſible taſte; and it produces but a very trifling alteration on the colour of ſyrup of violets.

We are not yet well acquainted with the manner in which magneſia acts on pure earths. We know, however, that it does not vitrify with either ſiliceous or aluminous earth ſeparately; but when heated with both together, it is ſuſceptible of fuſion.

Its action on barytes has not yet been examined.

The intimate nature of magneſia is not better known than that of barytes. It has never been ſhown by experiment to be a modification of ſome other ſaline ſubſtance, as ſome chemiſts have imagined it to be; for magneſia has not yet been either ſeparated into principles by analyſis, or imitated by a ſynthetic proceſs. In the preſent ſtate of chemiſtry, therefore, it is to be conſidered as a ſimple ſubſtance.

Pure magneſia, which Dr Black calls *cauſtic*, is uſed in medicine as an abſorbent and purgative. For heart-burnings and other complaints occaſioned by acidity, it is preferable to common magneſia; becauſe the carbonic acid which this laſt contains is diſengaged in the primary paſſages by the acids, and produces flatulencies, with all that train of complaints which accompany them: it preſerves fleſh for a long time, and even reſtores putrefied bile. Bergman aſcribes to it likewiſe the property of rendering camphor, opium, reſins, and gum-reſins, ſoluble in water, and of forming ſome valuable dyes; though cauſtic magneſia be ſcarce ſoluble in water. Theſe preparations are unknown in France *.

Species III. *Lime.*

Quicklime is a white ſubſtance, of more conſiſtency than the two preceding matters: it appears in the form of a grey white ſtone. Its taſte is hot, acrid, and urinous; it poſſeſſes this property in ſo conſiderable a degree as to inflame the ſkin when applied to it. Its ſpecific gravity is about 2.3; its form pulverulent and friable; it is found in places adjacent to volcanoes; as M. Monnet has obſerved on the hills of Auvergne.

Lime turns ſyrup of violets green, giving it a much more intenſe colour than it acquires from either barytes or magneſia: indeed, it almoſt deſtroys the original colour, and in a ſhort time produces in its ſtead a dirty yellow.

Lime, when expoſed to a ſtrong fire, ſuch as that of a glaſs-houſe, remains unaltered; and, in a ſolitary ſtate, it is not ſuſceptible of fuſion. Parker's burning-glaſs appears to have brought it to the beginning of fuſion; but the lime was placed on a ſupport of charcoal. When heated in a clay crucible, its edges ſometimes ap-

pear

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* We learn from Mongez, that borate of ſoda, and phoſphate of urine diſſolve magneſia with effervcſcence.—H.

pear to melt; but this phenomenon is occaſioned by its acting on the earth of the crucible.

When expoſed to the action of the air, lime ſwells, breaks, and falls into powder; it then increaſes greatly in bulk, and is called *lime ſlaked in the air.* Theſe phenomena are more remarkable, and take place more rapidly when the air is in a humid ſtate. This dry ſlaking produces heat; and the dilatation is ſo conſiderable as to burſt caſks, or other wooden veſſels in which lime may be contained. After being ſlaked with air, this ſubſtance appears under the form of a very fine white duſt; it has acquired a very conſiderable increaſe of weight, and its taſte is become much fainter. Theſe phenomena are occaſioned chiefly by the water contained in the atmoſphere, and the force with which the lime tends to unite with it. And by heating lime which has been ſlaked with air in a retort, till it becomes red-hot, water is obtained, and the lime returns to its original ſtate.

Water acts very powerfully on quicklime. Pour a ſmall quantity of that fluid on a quantity of lime; the water is inſtantly abſorbed; and the maſs of lime appears as dry as before; but it ſoon burſts and breaks into pieces. The heat excited in it by this operation is ſo ſtrong, as to produce a remarkable hiſſing noiſe; the water is reduced to vapour of a peculiar ſmell, which communicates a green colour to paper tinged with mallows. The lime ſoon falls down to a powder; and the heat, motion, and ſmoke, gradually diſappear. If the proceſs be performed at night, in a place perfectly dark, a great many luminous points are obſervable all over the ſurface of the lime. All theſe phenomena depend on the activity with which this ſalino-terrene ſubſtance unites with water. But, in order to produce them, we muſt employ but a very ſmall portion of the fluid; only ſo much as the lime can abſord without appearing wet. It appears that the heat diſengaged from theſe two bodies, when they combine with ſuch rapidity, changes their ſtate; and that the lime, when flaked, and reduced to a ſtate of pulverization, contains water in a dry and ſolid form. This dry ſtate of water —which takes place in many of the combinations in which heat performs a part, and produces ſolid compounds, whoſe ſpecific heat is leſs than that of the bodies of which they are formed,—has not yet ſufficiently engaged the attention of chemiſts; indeed it has been but lately obſerved. When lime has abſorbed as much water as it can contain, without becoming wet, it is then called *dry ſlaked lime;* water no longer excites any heat in it, and only diſſolves it, without producing any very diſcernible motion. By mixing lime with a proper quantity of water, we obtain milk of lime; and by adding ſo much water as may be neceſſary to effect a complete ſolution of this ſalino-terrenous matter, we produce a liquor perfectly tranſparent. Mr Kirwan ſays, that about 680 times its weight of water is neceſſary to maintain it in ſolution at the temperature of 60°.

This ſolution, which is known by the name of *lime-water,* is clear and limpid. It is but very little heavier than common water, has an acrid urinous taſte, communicates a deep green to ſyrup of violets, and even produces upon it an entire alteration of colour. Lime-water, when evaporated in cloſe veſſels, affords very pure water, leaving a reſidue of quick-lime at the bottom

tom of the veſſels: But this reſidue needs to be very ſtrongly heated, in order to ſeparate entirely the water which ſtill adheres to it. After which this fluid excites heat in it, in the ſame manner as before its ſolution.

Lime-water, when expoſed to the air, is covered with a dry pellicle, which becomes gradually thicker and more ſolid. If the firſt pellicle be taken off, a ſecond is formed, and this proceſs may be repeated till all the water be evaporated. Theſe pellicles have been improperly termed *cream of lime*. This was formerly thought to be a peculiar ſalt, formed by the union of the fineſt calcareous earth with water; and much has been written concerning this pretended ſalt of lime. But it is now well known from the experiments of the celebrated Black, that the cream of lime poſſeſſes ſaline properties leſs active than thoſe of lime, and that it is a peculiar neutral ſalt formed by the combination of lime, with a certain acid contained in the atmoſphere; and the cream is never formed on lime-water, except when it is expoſed to the air. We ſhall elſewhere examine this ſalt under the name of *carbonate of lime or chalk*. The manner in which the oxigenous and the azotic principles affect lime is not yet known: it is probable that this baſe abſorbs and fixes ſome part of gas azote, and at leaſt contains the baſe of this gas.

Lime combines with ſilicous earth in both the humid and the dry way. If ſand be mixed with lime newly ſlaked, or with quick-lime ſprinkled with a ſmall quantity of water at the time of mixing, the two bodies become conſiſtent, and form what is called *mortar*. This mixture is liable to many varieties; from the ſtate and quantity of the quick-lime, the quantity of water with which it has been ſlaked, the circumſtance of the ſand being mixed with it at the inſtant of its ſlaking, or not till ſome time afterwards; and from the ſize, the roundneſs, the inequality, the moiſture, or dryneſs of the ſand *. Mortar is alſo compoſed with clay baked for bricks, and with puzzolana, which is nothing but clay baked by volcanic fire, and altered by the contact of the air.

Though lime, as well as ſiliceous earth, be abſolutely infuſible by itſelf; yet if theſe two ſubſtances be heated together, the former in a greater proportion than the latter, they are ſuſceptible of fuſion, as has been obſerved by Meſſrs d'Arcet and Gerhard. Lime likewiſe melts with a quantity of aluminous earth equal to one-third of its own weight; and Mr Kirwan ſhows, that it has a greater affinity with this than with ſiliceous earth. A mixture of all the three ſubſtances melts eaſier and more completely than a mixture of lime with any one of the other two. Thus one part of lime and one of alumine will occaſion the fuſion of two parts, or even of two and an half of ſilice. From this fact we underſtand why ſo many ſtones, apparently hard, ſcintillating, and quartzoſe, melt notwithſtanding, when expoſed to a ſtrong fire. The combination, or even the mixture of calcareous earth and clay, with ſiliceous earth, occaſions this phenomenon.

It is not yet known in what manner lime acts on barytes.

One part of calcareous earth produces the fuſion of one

half

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* See Recherches par M. de la Faye, ſur la preparation que les Romains donnoient à la chaux, Paris 1777-8, premiere et ſeconde partie.—F.

half part of magneſia. The glaſs formed by this mixture, in fire completely diſſolves and reduces to fuſion a quantity of ſiliceous earth equal to the quantity of the lime. Accordingly, equal parts of magneſia, lime, and ſilice, when expoſed to fire together, afford a perfect glaſs.

The intimate nature of lime is unknown. The firſt chemiſts who attempted to explain by phyſical reaſonings the phenomena which lime diſplays in its combinations, and eſpecially when ſlaked, aſcribed them to the fixation of particles of fire in the calcareous ſtone during its calcination. Such was Lemery's theory. Meyer was of opinion that pure fire was not ſuſceptible of ſuch a combination, and that there was a peculiar acid which combined with it in the lime. This ſubtle kind of ſulphur was the *acidum pingue*, or *cauſticum* of that chemiſt. But this doctrine, which has ſince been repeatedly offered to the world under different names, is overthrown by a ſeries of experiments clearly demonſtrating its falſity. Many modern chemiſts think, that the matter of heat is combined in lime; and that by its diſengagement during the ſlaking of this ſubſtance, the light obſerved by Meyer and M. Pelletier, the ebullition and the evaporation of the water, as well as the peculiar fetid odour exhaled on the occaſion, are produced. It appears, however, from what has been ſaid, that the principles and compoſition of lime are ſtill unknown. Some very diſtinguiſhed naturaliſts have thought it to be in all probability a certain preparation of ſiliceous or aluminous earth effected by the organs of animals; but this is by no means certain. It is ſurely, however, formed by marine animals; its conſtituent parts are certainly united and combined under water during the life of thoſe organic beings; and azote is certainly *one* of its conſtituent parts: yet all this is inſufficient to determine the opinion of modern naturaliſts, who require accurate and repeated experiments.

Lime is made uſe of in many of the arts; more eſpecially in building. In medicine, lime-water is ſucceſsfully preſcribed in ulcerous caſes, &c. It has been thought a powerful lithontriptic. But long experience has ſhown, that it does not always operate the cures expected from it; and that where the uſe of it is too long continued, it produces on the animal fluids an alteration approaching to ſcurvy or ſepticity *.

CHAP.

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* Mr Kirwan ſays, that in hot water, lime is ½ more ſoluble than in water of the common temperature of 60° Fahrenheit. From Lavoiſier we learn, that 1000 parts of lime are capable of abſorbing and retaining, at the heat of 600° Fahrenheit, 228 parts of water. Bergman makes the ſpecific gravity of lime to be 2,720.—H.

CHAP. III.

Genus II. *Alkali Salts.*

ALKALIS come to be treated of before acids, becauſe they appear to be more ſimple and leſs decompoſable, and becauſe they reſemble in ſome properties the ſalino-terrene ſubſtances. They have an urinous acrid cauſtic taſte: they turn ſyrup of violets green, excite heat in uniting with water, abſorb both the moiſture and the carbonic acid of the atmoſphere, and diſſolve earths by the force of their tendency to combination *. Three ſpecies of alkalis are known; potaſh, or *vegetable fixed alkali*; ſoda, or *mineral fixed alkali*; and ammoniac, or *volatile alkali.*

Species I. *Potaſh.*

THIS ſpecies, which we denominate *potaſh*, has been called *vegetable, fixed alkali*; becauſe, though often met with in minerals, it is found in greateſt abundance in vegetables. It has likewiſe been named *alkali of tartar*, becauſe a conſiderable quantity of it may be obtained from this ſaline ſubſtance; which will afterwards come under our examination. Dr Black was the firſt who diſcovered potaſh in a ſtate of purity. Formerly this ſalt was called *cauſtic fixed alkali*, to diſtinguiſh it from common fixed alkali.

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* To theſe qualities may be added, the property of rendering oils miſcible with water.—H.

This ſalt, in a ſtate of conſiderable purity, is white and of a dry ſolid form: its ſapidity is ſo ſtrong, that it diſſolves the texture of the ſkin. It communicates inſtantaneouſly to the ſyrup of violets a deep green colour, much more obſervable than that which lime cauſes the ſame ſyrup to aſſume. It alters, and almoſt entirely deſtroys this colour, changing it to a brown yellow.

We know not in what manner light affects this ſalt.

Potaſh, when expoſed to the action of fire in cloſe veſſels, is inſtantly ſoftened, and by the time when it begins to appear red, becomes entirely liquid. If it be then poured on a ſmooth hard ſurface, it cools into a white, opaque, brittle maſs. It is not decompoſable by heat. A moſt intenſe heat, ſuch as that of the furnace of a glaſs-houſe, is requiſite to volatilize it. In all theſe operations it diſſolves part of the clay veſſels in which it is contained.

When expoſed to the open atmoſphere, it attracts moiſture ſtrongly, diſſolves into a liquid, and gradually paſſes into the ſtate of a neutral ſalt, by abſorbing the acid diffuſed through the atmoſphere. By this means, it acquires on ſuch occaſions an increaſe of weight, and becomes capable of efferveſcing with acids; which never takes place when it is in that ſtate of purity in which we have ſuppoſed it. To preſerve it pure, therefore, it muſt be kept in cloſe veſſels entirely full of it.

Potaſh diſſolves very readily in water; it then excites a conſiderable degree of heat, and exhales a fetid lixivious odour. The ſolution is colourleſs; and when very pure, affords no precipitate. To ſeparate it from the ſolvent, the ſolution muſt be evaporated to dryneſs in cloſe veſſels. If this operation be performed in open veſſels, the acid of the atmoſphere is attracted, and renders the pot-aſh effervеſcent. And this abſorption takes place ſo readily; that if a ſolution of this ſalt be expoſed to the open air for ever ſo ſhort a ſpace of time, it ſuffers an alteration, and is in fact neutralized. In a flaſk which it does not entirely fill, and which is frequently opened, it is liable to the ſame alteration. The action of oxigene and azote on this alkali is not known.

Potaſh combines with ſilice in the dry way, and cauſes it to melt together with itſelf: the two compoſe a tranſparent body, known by the name of *glaſs*. This body is liable to varieties from the various proportions in which the ſiliceous ſand and the fixed alkali are united in it. Two parts of the ſalt with one of earth afford a ſoft brittle glaſs, which attracts moiſture, and becomes at length opaque and fluid. This glaſs is ſoluble in water, on account of its containing ſo much more than an equal proportion of alkali. The ſolution is called *liquor of flints*. It at length depoſites part of the earth which it contains, in white ſemi-tranſparent flakes, apparently mucilaginous, and ſo light that they ſubſide but very ſlowly. Acids ſeize the alkali, and precipitate the earth, which is called *earth of flints*. But to make this proceſs ſucceed, care muſt be taken that the liquor of flints be not too much diluted by the water. In that caſe, the particles of the earth being too much divided, remain ſuſpended in the liquor, and evaporation is requiſite to produce the precipitate. Several chemiſts are of opinion, that earth of flints is not the ſame with ſiliceous earth; on which they think the alkali has produced an entire alteration. They think it to be more like aluminous earth, and believe that by combination with acids, it affords the ſame ſalts which are obtained by combining acids with aluminous earth. Such was the opinion of Pott and M. Baumé. But Scheele has ſhown, that that portion of the earth precipitated from liquor of flints, which is ſoluble in acids, is part of the aluminous earth of the veſſel in which the operation is performed, diſſolved by the mixture of alkali and ſiliceous earth.

The art of making glaſs is entirely chemical, as glaſs is nothing but a combination of fixed alkali with ſiliceous earth. The purity, the proportion, and the complete fuſion of theſe two ſubſtances by a fire ſufficiently intenſe, and kept up for a proper length of time, are the three conditions requiſite for the preparation of glaſs, of a proper tranſparency, of ſufficient hardneſs, and liable to no alteration from the attacks of air. We ſhall afterwards learn what other ſubſtances are mixed with theſe two in this compoſition, in order to render the glaſs more weighty and tranſparent, and to communicate to it ſeveral other properties which render it fitter for the purpoſes to which it is applied.

Potaſh acts not with the ſame force on aluminous as on ſiliceous earth: but the phenomena which it exhibits, when applied to alumine, are not yet well known.

This ſalt appears to be ſuſceptible of combination with barytes, magneſia, and lime. But its combinations with theſe ſubſtances have not yet been ſo accurately examined as to admit of our giving a particular account of them here.

Although potaſh has never yet been decompoſed; yet a number of facts with which the reader ſhall be hereafter made acquainted, concur to ſhow that it is not a ſimple ſubſtance. Stahl, who conſidered ſimple ſalts as a combination of earth and water, thought that fixed alkali differed from the acids only by containing a greater proportion of earth: and in this manner he accounted for its dryneſs, &c. Potaſh, in all probability is a combination of ſome one of the three preceding earths with azote. Some analogies lead me to think that it contains lime. But this conjecture is not yet ſupported by a ſufficient number of facts.

Potaſh is uſed in ſurgery to corrode the ſkin, and produce inflammation and ſuppuration in certain caſes *.

Species II. *Soda.*

This ſaline ſubſtance, which exhibits the ſame general characteriſtics with the foregoing, has received the name of *mineral fixed alkali*: It is found in abundance, combined with a peculiar acid ſalt in ſea-water, and in ſome ſpring-waters: ſometimes too it is met with in vegetables, but much ſeldomer than potaſh. This ſalt has been called *marine alkali*, from its making a part of marine ſalt; and *alkali*, or *ſalt of ſoda*, becauſe it is ofteneſt obtained from this ſubſtance. We prefer the ſimple name of *ſoda*.

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* Potaſh is extracted by *lixiviation* and ſubſequent *concentration*, from the aſhes of wood, ferns, and other vegetables. That which we uſually meet with in commerce, is manufactured chiefly in North America, or in the northern countries of the continent of Europe. However, this potaſh is not pure, but always more or leſs contaminated and neutralized.—H.

The taſte of ſoda is equally ſtrong and cauſtic with that of potaſh. It turns the ſyrup of violets green, and produces the ſame alteration as potaſh on this colour: it appears naturally in a dry and ſolid form. It melts in fire as it begins to become red-hot: a violent heat volatilizes it: it acts on almoſt all the veſſels in which it can be expoſed to heat.

When expoſed to atmoſpheric air, it attracts its moiſture, and the peculiar acid which it contains: ſo as to become gradually a neutral ſalt. The manner in which it is affected by oxigene and vital air is not yet known.

It diſſolves in water with heat, and the diſengagement of a fetid lixivious odour. It cannot be obtained pure after this ſolution but by evaporation in cloſe veſſels. The lixiviate, when expoſed to the air, readily abſorbs its acid, and becomes neutral. Therefore, to preſerve it pure, it muſt be kept in cloſe veſſels.

Soda readily combines with ſiliceous earth in the dry way, ſo as to compoſe glaſs. Glaſs-makers have even obſerved it to be more fuſible, and to adhere more readily and firmly with this earth than potaſh; to which they on this account prefer it. And therefore what was ſaid above concerning the uſe of potaſh in glaſs-making, may be applied to ſoda. Laſtly, this alkali, as well as potaſh, combines with acids and many other bodies, as we ſhall afterwards underſtand.

After this account of the properties of ſoda, we muſt obſerve, that there is no very remarkable difference between potaſh and ſoda when both are in a ſtate of purity. It is only in their combinations that the difference of their natures can be diſtinguiſhed. When combined with the ſame acid, they afford neutral ſalts totally different from each other; and this is the more ſurpriſing becauſe it is impoſſible to diſtinguiſh the one from the other when they are in a pure cauſtic ſtate, as we have here examined them. Bergman adds another diſtinctive property of theſe ſalts which is well worth knowing; they have not the ſame affinity with acids. Potaſh has a ſtronger affinity with theſe ſaline ſubſtances than ſoda: and is capable to decompoſe neutral ſalts, conſiſting of combinations of the latter. We ſhall take farther notice of this when we come to examine ſecondary or neutral ſalts.

The compoſition or intimate nature of ſoda is equally unknown as that of potaſh. The ſame analyſis leads me to think that ſoda, as well as potaſh, is a combination of an earth with azote; and that it is the difference of the earthy baſe which forms the characteriſtic difference between the two ſalts. Magneſia is poſſibly the baſe of ſoda, as I have for ſome years hinted in my lectures, and M. Lorgna has ſince attempted to prove. But the facts on which this opinion is founded, are not ſufficiently exact and numerous to juſtify our conſidering it as a certain truth. As to its uſes, it is employed in making glaſs, in preparing ſoap, &c. *.

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* The aſhes of ſea-plants, which are annually burnt to fuſion around the coaſts of Scotland and its contiguous iſlets; and are ſold, under the name of *kelp*, are valuable only for the ſoda which they contain. Soda is likewiſe produced, ſeparately, by nature, in two lakes in Egypt. It is there known by the name of *natron*.—H.

Species III. *Ammoniac.*

WHAT we call *ammoniac* is a ſalt commonly known by the name of *volatile alkali.* It is diſtinguiſhed from the two foregoing ſalts by a keen ſuffocating ſmell and a remarkable volatility. This ſalt, like the fixed alkalis, was not known in a ſtate of purity before the ingenious experiments of Black and Prieſtley. A certain imperfect neutral ſalt was miſtaken for it, which is ſolid and cryſtalliſed, and poſſeſſes indeed ſome of the properties of volatile alkali, but is really a compound of two ſaline ſubſtances. The property of effervefcing with acids, which has been aſcribed to volatile alkali, belongs only to that neutral ſalt, which will be afterwards deſcribed.

That which is known in the laboratory under the name of *cauſtic*, or *fluor. volatile alkali*, and in pharmacy by the name of *volatile ſpirit of ſal ammoniac*, is not pure ammoniac; it is only a ſolution of ammoniac in water. Dr Prieſtley has ſhown, that by the operation of a gentle heat, a permanent gas may be extracted from it; and that the water, when deprived of this gas, gradually loſes its alkaline properties, This aëriform fluid is ammoniac, and is known by the name of *ammoniac gas.* This is the body whoſe properties we muſt examine, if we wiſh to know thoſe of genuine *volatile alkali;* as Macquer has very properly obſerved.

To obtain this elaſtic fluid, put into a ſmall retort or a glaſs matraſs a certain quantity of liquid ammoniac. Adapt to the retort, or the matraſs, a curved tube or ſyphon; the extremity of which is to be immerſed into a pneumato-chemical machine filled with mercury; ſo that it may be received under an inverted glaſs filled with the ſame metallic fluid. Heat the bottom of the retort or matras with burning charcoal or the flame of ſpirit of wine. Suffer the firſt part of the elaſtic fluid, which is moſtly common air from the veſſel and the tube, to eſcape; and as ſoon as the ebullition becomes ſtrong, collect the gas in the inverted glaſs. The diſtillation muſt not be carried ſo far as to evaporate the water; or at leaſt the tube which is uſed ſhould in the middle ſwell into a bowl that may be kept cool, ſo as to condenſe the vapour: the ammoniac gas will then be obtained very dry and pure.

The gas thus obtained reſembles air, and has the ſame tranſparency and elaſticity. It is rather lighter, however; its ſmell is more penetrating; and its taſte is acrid and cauſtic. It inſtantly converts the blue colour of violets, mallows, and radiſhes, into a deep green, but does not alter it, as the pure fixed alkalis do. It kills animals, and corrodes the ſkin, if expoſed for any time to its contact.

Though it does not ſerve to maintain combuſtion, but extinguiſhes bodies in inflammation, yet it increaſes before extinguiſhing the flame of a wax-candle: it renders its bulk ſomewhat more conſiderable, and cauſes it to aſſume a pale yellow colour round the edge. This fact proves that ammoniac gas is partly inflammable.

Porous bodies, ſuch as charcoal, ſponge, &c. abſorb it.

Dr Prieſtley has diſcovered, that the electric ſpark, in paſſing through ammoniac gas, renders its bulk three times greater than before, and diſengages from it a portion of hydrogenous gas. The cauſe of this phenomenon is hitherto unknown; only it appears that the ammoniac is decompoſed in this experiment, and that the two matters, of which, as we ſhall preſently ſhow, it is compoſed, are ſeparated, and paſs into the ſtate of elaſtic fluids.

Ammoniac gas is one of thoſe elaſtic fluids which heat dilates the moſt. Atmoſpheric air does not combine with this gas; it only dilutes and divides it. The action of vital air on this fluid has not yet been examined.

Water readily abſorbs ammoniac gas: if in the ſtate of ice, it immediately melts with cold; but on the contrary, this gas communicates heat to fluid water. Water ſaturated with this gas, or liquid ammoniac, is the ſubſtance known by the name of *fluor* and *cauſtic volatile alkali.* We ſhall hereafter ſee that the pureſt and moſt concentrated volatile alkali is prepared by receiving the gas into diſtilled water till the liquid be ſaturated with it.

Ammoniac gas has no diſcernible action on earths or ſalino-terrene ſubſtances; but it acts vigorouſly on acids and a number of neutral ſalts, as we ſhall hereafter ſee. Liquid ammoniac has the ſame properties as the gas; only, it poſſeſſes them in a leſs eminent degree: For the gaſeous aggregation being, according to one of the laws of affinity, much weaker than that of liquids; of conſequence, ammoniac gas muſt have a greater tendency to combination than liquid ammoniac.

This ſalt has been conſidered as a combination of fixed alkali with a combuſtible ſubſtance. What gave riſe to this conjecture was, that, in many inſtances, fixed alkalis, when heated with inflammable matters, produce ammoniac. But it was not known whether, on ſuch occaſions, fixed alkali entered entire into the compoſition of ammoniac, or only ſupplied a peculiar principle, which, by combining with part of the combuſtible matter, formed this ſalt. The nature of ammoniac is at preſent ſomewhat better known. The fine experiment of Dr Prieſtley, in which he changed alkaline into inflammable gas, by means of the electric ſpark, made ſeveral chemiſts ſuſpect this laſt ſubſtance to be one of the principles of ammoniac. M. Berthollet having engaged in a particular ſeries of experiments with a view to determine this, has at length ſhown ammoniac to be a compound of the hydrogenous and the azotic principles, with a certain quantity of the caloric. He has drawn this induction from obſerving the action of oxigenated muriatic acid on ammoniac, the decompoſition of ammoniacal nitrate in cloſe veſſels, and the reduction of metallic oxides by means of ammoniac. Each of theſe facts will be particularly examined in our hiſtory of the compound ſubſtances into which ammoniac enters. Here we ſhall content ourſelves with obſerving, that by heating combinations of the oxides of copper and gold with ammoniac, water and gas azote are obtained, and the metals are reduced. In ſuch operations the ammoniac is decompoſed, and its hydrogene combining with the oxigene of the metallic oxides, forms the water; the metals are left pure, and the azote, the other principle of the ammoniac, becoming free, combines with the caloric, and the two are diſengaged in gas azote. Berthollet concludes ammoniac to conſiſt of ſix parts of azote and one of hydrogene, with a certain quantity of caloric [*].

Ammoniac diluted in water is adminiſtered in a great many diſeaſes. It is aperient, and powerfully inciſive. It acts ſtrongly on the ſkin; it is preſcribed as a remedy for the bite of vipers, and for cutaneous and venereal complaints, &c.

As it is acrid and cauſtic, it is to be very cautiouſly uſed. Externally applied, it is very ſerviceable in diſcuſſing tumours, eſpecially ſuch as are formed by coagulated milk, lymph, &c. I have preſcribed it ſucceſsfully in theſe caſes: it is a ready cure for burnings; and is often ſucceſsfully applied for chilblains, &c. It has been long uſed, and under a variety of names, as a moſt active ſtimulant in caſes of ſyncope, apoplexy, &c. But it ſhould be uſed in very moderate quantities in theſe latter caſes: it is dangerous to adminiſter it internally, unleſs diluted in a large quantity of water. Alarming excoriations have ſometimes been produced on the duct of the œſophagus and the membranes of the ſtomach, in caſes where it has been raſhly adminiſtered.

CHAP.

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[*] According to Dr Auſtin, the azote is in proportion to the hydrogene, as 121 to 32.—H.

CHAP. IV.

Genus III. *Acids.*

ACIDS are known by their ſour taſte when diluted in water; they convert blue vegetable colours to red; many of them appear under a gaſeous form; they combine rapidly with alkalis; they act much more powerfully than alkalis on combuſtible bodies, often reducing them to a ſtate of calcination. As inflammable matters, eſpecially metals, are found to contain a conſiderable quantity of oxigene after they have been expoſed to the action of acids; while theſe again are found to have paſſed at the ſame time into a combuſtible ſtate: from theſe facts it may be inferred that acids are by no means the ſimple bodies they were thought to be, but are in general compounds of an inflammable matter, combined with oxigene.

We are acquainted with ten different ſpecies of acids in the mineral kingdom. We find alſo, in the ſame diviſion of nature, the phoſphoric acid, united with iron, lead, and lime.

The carbonic acid.
The muriatic acid.
The fluoric acid.
The nitric acid.
The ſulphuric acid.
The boracic acid.

The molybdic acid.
The tunſtic acid.
The arſenic acid.
The ſuccinic acid.

We ſhall here treat of the firſt ſix, which are the moſt plenteous and beſt known; the other four will be examined elſewhere.

Species I. *The Carbonic Acid.*

We give the name of the *carbonic acid* to an acid which occurs in great abundance through the whole of nature, and which appearing often in the ſtate of an aëriform fluid, was at firſt called by the Engliſh *fixed air*; afterwards by Meſſrs Bewly and de Morveau *the mephitic acid*; by Macquer *mephitic gas*; by Bergman *the aërial acid*; and by Bucquet *the cretaceous acid*. The propriety of the denomination which we have adopted will afterwards appear.

This ſubſtance was not always thought to be an acid. Its leading properties were obſerved by Paracelſus, Van Helmont, Hales, &c. But we are indebted to Meſſrs Black, Prieſtly, Bewly, Bergman, and Chaulnes for our knowledge of its acidity.

The gaſeous carbonic acid poſſeſſes all the apparent characteriſtic properties of air. Like air, it is inviſible and elaſtic; and when incloſed in a glaſs veſſel, or floating in the atmoſphere, it cannot be certainly diſtinguiſhed from that fluid. It is one of the principles of atmoſpheric air, but the moſt ſcanty in the compoſition.

compoſition *. It is found perfectly pure in ſubterraneous cavities, which it entirely fills, as in the *grotto del cane.* It is combined with a greater number of natural bodies, ſuch as mineral waters and many neutral ſalts; ſpirituous fermentation produces great quantities of it. It is alſo formed by reſpiration and the combuſtion of coals: Laſtly, it is conſtantly exhaled from all parts, and more eſpecially from the leaves, of plants in the ſhade.

Though this acid, in the ſtate of an elaſtic fluid, has all the appearance of air, yet it poſſeſſes different phyſical properties; its ſpecific gravity, for inſtance, is double that of air. Like all other fluids, it may be poured from one veſſel into another; it flows from the cock of a wine-caſk, after the wine is drawn off; its taſte is pungent and ſubacid; it is inſtantaneouſly fatal to animals, becauſe it affords no ſupply for reſpiration; it extinguiſhes flaming tapers, and all bodies in combuſtion. It communicates to the tincture of turnſole a bright red colour. That colour vaniſhes gradually in the air as the acid evaporates. It produces no alteration on the colour of violets, as it acts but very feebly on very deep and fixed colours.

This acid has but a very faint tendency to combination; the weakeſt indeed of all the bodies of the kind. It

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* M. Lavoiſier's ingenious experiments have led him to conſider atmoſpheric air as a compound of vital air, carbonic acid, and azotic gas, moſt commonly in the following proportions.

Vital air,	27
Carbonic acid,	01
Gas Azote,	72
Total	100

It ſuffers no diſcernible alteration from the contact of light.

Heat dilates it, but produces no change in the mixture.

It mixes with vital air, without ſuffering any alteration; and the mixture will maintain reſpiration as long as the carbonic acid does not exceed a third part of it. On this account, it admits of being uſed as a remedy in diſeaſes of the lungs.

It combines with water but very ſlowly. By ſhaking theſe two fluids together, ſo as to bring them as much as poſſible into contact with one another, they are made to unite and form an acidulous liquor. Bergman gives to this ſolution the name of *aërated water*. But this name belongs more properly to water containing atmoſpheric air, which it may ſerve to diſtinguiſh from boiled water that has been deprived of its air by heat. The colder water is, the more of the carbonic acid does it diſſolve. But there is a point of ſaturation; even the coldeſt water cannot abſorb a quantity greater than is equal to its own bulk.

Water ſaturated with carbonic acid is ſomewhat heavier than diſtilled water. Agitation makes it ſparkle; it has a pungent, acidulous taſte, and reddens the tincture of turnſol. It is decompoſable by heat; which ſoon brings it to a ſtate of ebullition, and diſengages the elaſtic fluid. The contact of air produces the ſame effect more rapidly in proportion as its temperature is higher. Therefore, in order to preſerve this acidulous liquor, it muſt be incloſed in veſſels properly ſtopped, and ſtanding in a cool place, or under ſtrong compreſſion.

This acid ſolution abounds throughout nature. Of it acidulous and gazeous waters, ſuch as thoſe of Pyrmont, Seltz, &c. conſiſt.

As this acidulated water is a remedy in all putrid diſorders, either by drinking or bathing, naturaliſts have invented an apparatus for impregnating with eaſe, and with all poſſible quickneſs, any quantity of water with as much of the carbonic acid as it can maintain in ſolution. Dr Prieſtley, in the year 1772, gave the firſt account of a proceſs for acidulating water that was offered to the public. Dr Nooth has invented a machine for this purpoſe, which has been improved by Mr Parker, and ſtill farther improved by Mr Magellan. It is at preſent to be found in all philoſophical laboratories. There is an excellent deſcription, and an engraving of it, in Dr Prieſtley's Experiments on the different kinds of Air, p. 112 to p. 118; and in Mr Magellan's letter in the ſame work, vol. v. page 83.

The carbonic acid does not act upon ſiliceous earth. It is well known that acidulated water alone never cryſtalliſes ſiliceous earth; as was ſome years ſince repreſented to the public.

The carbonic acid unites with alumine, barytes, and magneſia. With theſe ſubſtances it forms various neutral ſalts, which we ſhall afterwards have occaſion to examine.

The combination of this acid with lime diſſolved in water, gives riſe to an invariable phenomenon, which always indicates the preſence of the acid. As ſoon as it touches the liquid, it produces white clouds, which ſoon thicken and form a plenteous precipitate. Theſe clouds are owing to the chalk, or carbonate of lime, formed by the combination of lime with the carbonic acid. This new ſalt, not being ſoluble in pure water, is ſeparated, and ſubſides to the bottom of the fluid. Lime-water is therefore a teſt, by which we may diſtinguiſh the nature and the quantity of the acid under examination. If, after this precipitation, more of the acid be added, the precipitate will again be diſſolved by the additional quantity of the carbonic acid, and will then diſappear. Here is a ſecond characteriſtic by which this acid may be known. The chalk thus diſſolved by the addition of a ſecond quantity of the carbonic acid, is again precipitated when the liquor is heated or expoſed to the air, or laſtly, by all the proceſſes which carry off the ſuperfluous quantity of the carbonic acid. Thus, I have remarked, that the cauſtic fixed alkalis and pure ammoniac, when poured into a ſolution of chalk with the carbonic acid, cauſe a precipitation by abſorbing part of the acid.

Acidulated water, if poured into lime-water, produces upon it preciſely the ſame effects.

The carbonic acid combines rapidly with the three alkalis. If a ſmall quantity of pure cauſtic fixed alkali, in a liquid ſtate, be put into a veſſel filled with this acid, obtained from chalk or from beer in a ſtate of fermentation; and the mouth of the veſſel be immediately cloſed with a wet bladder: the bladder will be ſeen to contract gradually, on account of the vacuum produced in the veſſel by the alkali abſorbing the carbonic acid. The combination of theſe two acids is attended with heat; and the ſides of the veſſel are ſoon covered with cryſtals which become gradually larger. This ſalt is called *carbonate of potaſh*, or *carbonate of ſoda*, according as the one or the other of theſe fixed alkalis is employed. Theſe two genuine neutral ſalts were formerly called *ſalt of tartar*, and *ſalt of ſoda*. We ſhall examine their properties in the following chapter.

Ammoniac gas, and the aëriform carbonic acid brought into contact in a cloſe veſſel, alſo produce inſtantaneouſly a vacuum, heat, and a thick white cloud which forms into regular cryſtals, or ſimply into a cruſt, on the ſides of the veſſels. This is an imperfect neutral ſalt, to which we may give the name of *ammoniacal carbonate*, and which was formerly called *concrete volatile alkali*, *Engliſh ſalt*, &c.

The carbonic acid does not adhere to all of theſe baſes with the ſame force. According to Bergman, barytes is the ſubſtance with which it has the greateſt affinity; next in order come lime, potaſh, ſoda, magneſia, and ammoniac. We will have occaſion in the hiſtory of neutral ſalts to take notice of the facts on which Bergman has eſtabliſhed this order of affinities.

The nature and compoſition of this gaſeous acid, have for ſome years much engaged the induſtry of chemiſts. Prieſtley, Cavendiſh, Bergman, and Scheele, ſeem to agree in thinking it a compound of vital air with phlogiſton. But as the exiſtence of that principle has been with reaſon queſtioned by a number of celebrated French chemiſts, who have urged many difficulties and objections againſt it, to which no ſatisfactory anſwer can be given, we cannot therefore admit of this theory. I once thought that the carbonic acid might be a compound of inflammable gas with pure air; but the diſcovery of the nature and the decompoſition of water renders that conjecture improbable; and M. Lavoiſier has ſupplied it in its room a fact ſupported by demonſtrative evidence.

This chemiſt, to whom the ſcience is indebted for ſo many ingenious and nice experiments, burnt a certain quantity of charcoal, deprived of all its hydrogenous gas by a previous calcination in cloſe veſſels,—in inverted glaſſes, filled with mercury above a portion of air: for he had obſerved, that if the operation were performed without the precaution of calcining the coal, drops of water would be obtained, and would neceſſarily render the calculation inaccurate. This operation was performed by means of a quarter of a grain of agaric tinder, placed on a bit of coal, and covered with a very ſmall quantity of phoſphorus: a piece of iron wire bent, and made red hot, paſſed through the mercury, ſo as to kindle the phoſphorus; the phoſphorus communicated the inflammation to the agaric tinder, which again communicated it to the coal; the inflammation was very rapid, and accompanied with much light. The whole apparatus being cold, M. Lavoiſier introduced into the glaſs a portion of liquid fixed cauſtic alkali; which abſorbing the acid formed during the combuſtion, left part of the vital air as pure as at the beginning of the experiment. This chemiſt is of opinion, that in this experiment the oxigene, which by combining with caloric formed the vital air,—produced a portion of the carbonic acid by combining with the matter of the coal, while the other principle of the ſame vital air was diſengaged under the form of heat and light. A portion of aſhes remained; and the quantity of the acid formed was equal in weight to the vital air conſumed; and the weight which the coal had loſt. From a number of experiments of this kind, M. Lavoiſier concluded, that a quintal of the carbonic acid, the name of which the reader may now perceive to be founded on its nature, conſiſts of about 28 parts of pure carbonaceous matter, and 72 of oxigene.

He thinks, that in the reſpiration of animals, a real carbonaceous matter is actually diſengaged from the blood, which by combining with the oxigene of the atmoſphere, forms the carbonic acid, which is conſtantly produced by reſpiration; and that in the ſame manner the carbonic acid, diſengaged in ſpirituous fermentation, is produced by the combination of the carbonaceous matter of ſugar with the oxigenous part of water.

Several philoſophers have obſerved, that this acid, in a ſtate of fluid elaſticity, poſſeſſes the property of preſerving animal ſubſtances, retarding their putrefaction, and even reſtoring them to a ſound and freſh ſtate after putrefaction has begun to take place. From this fact Macbride has inferred, that the acid unites with the body, thus reſtoring to it what it loſt by putrefaction. This latter phenomenon, in his opinion is occaſioned by the natural decompoſition of organic matters, and the diſſipation of the carbonic acid they contain, which he calls *fixed air*; and therefore he aſſerts the uſe of this acid to be indiſpenſably neceſſary, in order to afford to animals a ſupply of what they are ſo conſtantly loſing, and to reſtore the fluids when altered by motion and heat. He acknowledges the exiſtence of this acid in freſh vegetables, more eſpecially in ſuch as are ſuſceptible of fermentation; as a decoction of barley which has been ſuffered to germinate, the infuſion of raiſins, &c. all of which, he thinks, may be with equal propriety preſcribed in diſeaſes occaſioned by the ſeptic motion of the humours; ſuch as the ſcurvy.

Water impregnated with the carbonic acid has been alſo propoſed as a remedy in putrid bilious fevers; and has been uſed with ſucceſs in a number of inſtances. The Engliſh are ſaid to uſe the carbonic acid, mixed in a low and unequal proportion with common air, in diſeaſes of the lungs.

It has been ſtrongly recommended as a lithontriptic, or ſolvent of the ſtone in the bladder. But there is no well authenticated inſtance of its being ſucceſsfully uſed in France again this dreadful diſtemper. Beſides, this is contradictory to what Scheele and Bergman have diſcovered concerning the ſtone in the bladder; of which we ſhall elſewhere ſpeak.

The newſpapers have given accounts of a number of cancerous caſes cured in England by the uſe of carbonic acid. But we can aſſert, that we have often ſeen it uſed in ſuch caſes, and have even tried it ourſelves, ſtill without effect. After the firſt applications, the cancerous ulcer ſeems to aſſume a more favourable aſpect; the ſanies which uſually flows from it becomes white, conſiſtent, and ſomewhat pure; the fleſh aſſumes a freſh lively colour; but theſe flattering appearances are fallacious, and do not continue; the ulcer ſoon returns to its former ſtate, and its progreſs goes on as before.

The period of the firſt diſcovery of this acid by Dr Black is to be conſidered as one of the moſt illuſtrious æras of chemical ſcience. To point out the influence of this diſcovery upon the ſcience, we ſhall here offer the following remarks. 1. It has made us acquainted with a peculiar acid. 2. It has explained the cauſe of the effervefcence of the common alkalis; chalk, calcareous fpar, and magnefia, when mixed with acids ftronger than themfelves. 3. It has enabled us to diftinguifh all alkaline matters as exifting in two ftates, *pure and cauftic*, or *foft, with the property of caufing effervefcence*. 4. It has thrown new light on the hiftory of the elective attractions of ammoniac and chalk for the acids. 5. It has furnifhed us with one of the firft inftances of an acid preferring lime to the fixed alkalis. 6. The hiftory of places containing mephitic air, caverns which are inftantly fatal to the life of animals, is become fince this difcovery more fimple and intelligible. 7. To the former analyfes of waters, we have been enabled to add by this difcovery an accurate knowledge of gafeous, fpirituous, and acidulous waters; fo that we can now produce by rule the moft perfect imitations of them. 8. It has likewife made us much better acquainted with the folutions of iron contained in various waters; and has taught us how to make up martial waters exactly refembling thofe of nature. 9. It has made us acquainted with a new clafs of neutral falts alkaline and metallic, which have the carbonic acid for one of their principles, and to which we fhall therefore give the name of *carbonates* in this work. 10. It has opened a new tract for the refearches of naturalifts and chemifts, and has roufed that ardour for fuch purfuits, to which we are indebted for all the fine difcoveries which have been made fince that period. The name of Black will therefore be famous in the annals of chemiftry as long as the fcience fhall be cultivated.

As to the production of this acid by the electric fpark paffing through vital air, we muft obferve, that in the experiments of M. Landriani, the iron uſed as the conductor of the electric fluid, is evidently the cauſe of the phenomenon by means of the plumbago, or carbure of iron, which it contains. The trivial quantity of the acid obtained, is an unequivocal proof of this.

There are, no doubt, many caſes in which the carbonic acid is decompoſed and reſolved into its principles, as well as other acids: Thus, for inſtance, water ſaturated with this acid is much fitter than diſtilled or common water for the production of vital air on leaves expoſed to the rays of the ſun: the vegetable ſubſtance ſeems to abſorb the carbonaceous matter, while the light, acting like heat, contributes by ſeparating the oxigene, to the production of vital air. It is likewiſe very remarkable, that certain oxides of iron, diſtilled in a pneumato-chemical machine, afford only carbonic acid as they paſs to the ſtate of æthiops or black oxide of iron. This depends either on the carbonaceous matter, or the plumbago contained in ſeveral kinds of iron. The carbonaceous matter, by abſorbing part of the oxigene of the iron, forms the acid which is diſengaged. Theſe newly diſcovered facts will be explained more at length in ſome of the following chapters of this work[*].

Species II. *The Muriatic Acid.*

In the laboratories, the name of *marine acid*, or *ſpirit of ſalt*, or *liquid muriatic acid*, is given to a fluid of the conſiſtency of water, of a taſte ſtrong enough to

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[*] According to Kirwan, the proportion of carbonic acid to that of common air, is, as 68,74 to 45,69; Lavoiſier makes it 69,50 to 48,81. The proportion of the carbone to the oxigene, in carbonic acid, is as 12,0288 to 56,687.—H.

corrode our organs when it is concentrated; but which, when diluted in water, affects the tongue only with a ſourneſs and ſtipticity. This fluid, when perfectly pure, is abſolutely colourleſs. When it is red, or citron-coloured, like the marine ſalt of the ſhops, it owes its colour to ſome combuſtible ſubſtances, frequently to iron, which alters it. This acid is obtained from marine ſalt or muriate of ſoda, as we ſhall ſee in the hiſtory of that ſalt. If ſtrong and concentrated, it exhales when expoſed to the air a white vapour or ſmoke. It has a lively penetrating ſmell, which when faint or much diluted, reſembles the ſmell of citrons, or the apple called the *golden rennet.* It is then called the *fuming muriatic acid.* Its vapour riſes moſt copiouſly when the air is moiſt. If, on opening a flaſk full of this acid, you put your hand to its orifice, you feel a ſenſible heat; which is occaſioned by the combination of the acid in the ſtate of vapour with the water of the atmoſphere.

The muriatic acid communicates a deep red to the ſyrup of violets, and all blue vegetable colours, but does not abſolutely deſtroy them. This liquor, however concentrated and fuming, is not muriatic acid in a pure and ſeparate ſtate; but muriatic acid combined with a conſiderable quantity of water. Dr Prieſtley has eſtabliſhed this truth beyond a doubt, by ſhowing that this acid may be reduced to a gas, and rendered permanent in that ſtate, over a portion of mercury, by the temperature and preſſure of the atmoſphere: we muſt therefore examine the properties of this gas, if we wiſh to acquire a knowledge of thoſe of the muriatic acid, unmixed and in a ſtate of purity.

The muriatic acid gas is obtained by heating the liquid fuming acid in a retort, the extremity of which enters a bell-glaſs full of mercury. The gas being much more volatile than the water, paſſes through the retort into the glaſs; it diſplays all the apparent properties of common air, but is more ponderous. It has a keen penetrating odour; and is ſo cauſtic that it inflames the ſkin, and often occaſions violent itchings. It ſuffocates animals, and extinguiſhes the flame of a taper, after magnifying it and cauſing it to aſſume a green or bluiſh flame round its edges. Spongy bodies abſorb this acid.

Light does not appear to alter it in any ſenſible degree. Heat rarefies it, and increaſes its elaſticity amazingly. Atmoſpheric air, mixed under bell-glaſſes with muriatic gas, cauſes it to aſſume a fumy or vaporous form, and is gently heated; from which it appears that a combination actually takes place. When the air is humid, theſe vapours are more diſcernible: M. d'Arcet has obſerved that they are not perceptible on the tops of high hills, where the air is very dry. The white vapours exhaled by the muriatic acid gas are therefore owing to the water contained in the atmoſphere. Neither the liquid acid nor the gas abſorbs vital air in a ſtate of elaſticity, in any ſenſible degree; yet ſome properties, which we ſhall mention by and by, enable them to combine with the oxigenous principle. It is aſſerted that the liquid muriatic acid may be cauſed to abſorb a portion of vital air, by ſhaking them violently together.

The muriatic acid gas combines rapidly with water. Ice, on coming into contact with it, inſtantly melts, to abſorb it. Water uniting with this gas acquires a conſiderable heat. When ſaturated with it, it cools and becomes the ſame with the liquid acid from which the gas was obtained ; it exhales white vapours, is colourleſs, reddens ſyrup of violets, &c. We ſhall afterwards ſee, that the moſt concentrated and pure liquid muriatic acid is obtained by ſaturating pure water with the elaſtic fluid.

The muriatic acid gas has no power of action on ſiliceous earth ; it combines with aluminous earth, and by this combination forms aluminous muriate.

It unites with the ſalino-terrene ſubſtances, forming in combination with them barytic, magneſian, and calcareous muriates.

Its combination with potaſh is *the febrifuge ſalt of Sylvius*, or muriate of potaſh ; with mineral alkali or ſoda, it gives marine ſalt, common ſalt, or muriate of ſoda.

The muriatic acid gas when brought into contact with ammoniac gas, acquires a conſiderable heat. The two elaſtic fluids penetrate each other, a white cloud inſtantly riſes, the mercury is elevated in the glaſſes, and the ſides of the glaſſes are ſoon covered over with ramified cryſtals, which are ſal ammoniac, or ammoniacal muriate. If the two gaſes be very pure, they diſappear entirely when the concretions are formed, and the heat diſengaged. This experiment among others proves, 1. That bodies which paſs from a liquid to a ſolid ſtate, abſorb in their tranſition a certain quantity of the caloric principle, or the matter of heat ; for the cauſe which converts the muriatic acid into a gas, is its receiving an additional quantity of heat. 2. That the heat abſorbed by elaſtic fluids, in their *aërification*, is diſengaged when they return to a liquid or ſolid ſtate. 3. That the elaſticity of fluids is produced by their abſorbing and combining with heat; and that all aëriform fluids are compound bodies, which owe their form to fixed heat, or the caloric principle, as we have elſewhere ſhown.

The muriatic acid abſorbs the carbonic acid; but the reciprocal action of theſe two acids has not yet been properly examined. The muriatic is known to be the ſtronger of the two; for it diſengages the carbonic from all its baſes, and enters itſelf into combination with them. Bergman arranges its attractions for the different alkaline baſes in the following order, proceeding from that with which it has the ſtrongeſt to that with which it has the weakeſt affinity: barytes, potaſh, ſoda, lime, magneſia, ammoniac, alumines.

The intimate nature of the muriatic acid, and the principles of its compoſition, are unknown. Beccher imagined it to conſiſt of ſulphuric acid with *mercurial* earth; becauſe he had obſerved that acid to have a ſtrong affinity, and combine very readily, with all the bodies in which he admitted the exiſtence of this principle, ſuch as arſenic, mercury, &c. Stahl has not illuſtrated Beccher's opinion concerning this acid. And among all the ingenious experiments of the moderns, there is none which throws any light on the conſtituent principles of the muriatic acid. As its baſe is unknown to us, we cannot determine whether it admits of two ſtates of ſaturation with oxigene; in one of which, the baſe being completely ſaturated, the acid muſt be ſtronger, while in the other the baſe being combined with a ſmaller quantity of oxigene, the acid muſt be weaker, according to what has been obſerved of the nitric, the nitrous, the ſulphuric, and the ſulphureous acids. Even the exiſtence of oxigene in the muriatic acid has not yet been fully evinced; it is only from analogy that it has been admitted.

Scheele is the only chemiſt who has done any thing of conſequence on this head. In the year 1774, he made an important diſcovery concerning the different ſtates in which this acid exiſts. By diſtilling a quantity of muriatic acid upon oxide of manganeſe, he obtained this acid in the form of a yellowiſh gas, of a very pungent ſmell, amazingly expanſive, and capable of diſſolving any metal with facility, mercury or gold not excepted. He thought that, in this inſtance, the manganeſe, which he imagined to be very greedy of phlogiſton, abſorbed the phlogiſton of the muriatic acid; and he therefore called this acid, after it had undergone this operation, *dephlogiſticated marine acid;* and thought that it diſſolved gold, from its avidity to unite with a new portion of phlogiſton. No unequivocal experiment, however, demonſtrated the exiſtence of the inflammable principle in this acid: and in the year 1780, I ſuſpected that it was the baſe of vital air contained in the manganeſe, which entered into union with the muriatic acid; as may be ſeen in the firſt edition of my Elements under the articles *Aqua Regia* and *Manganeſe, &c.* M. Berthollet, my fellow-academician, has ſhown that conjecture to be a certain truth, by a ſeries of accurate and ingenious experiments.

A diſtillation of the muriatic acid on oxide of manganeſe, afforded him yellow vapours without the help of fire. If the retort be heated, and the vapours received in flaſks full of water, and immerſed in ice, a very ſmall portion of the acid is diſſolved, but the water is ſoon ſaturated; after the ſaturation of the water, the reſt of the gas aſſumes a concrete form, and falls in cryſtals to the bottom of the liquor. This ſalt melts, and riſes in bubbles with the moſt moderate heat.

The oxigenated muriatic acid in a liquid form, or diſſolved in water, has, according to M. Berthollet, an harſh though not an acid taſte; it whitens and deſtroys vegetable colours, without changing them firſt into a red; it neither expels the carbonic acid from its baſes, nor produces any efferveſcence with alkaline ſubſtances ſaturated with that acid; in ſhort, it poſſeſſes not the uſual properties of acids. If heated with quicklime, it efferveſces, and gives out vital air, ſo that the remains is nothing but calcareous muriate; which is evidently produced by the diſengagement of the oxigene with which the acid was ſaturated. The oxigenated muriatic acid produces likewiſe an efferveſcence when it combines with pure ammoniac. The reſult of this combination is, on the one hand, water; on the other, azotic gas. In this inſtance, the oxigenated muriatic acid and ammoniac are both decompoſed; the hydrogene, which is one of the principles of the ammoniac, unites with the oxigene, with which the muriatic acid is ſuper-ſaturated, and by their union the water is formed; while again, the azote, the other principle of the ammoniac, uniting with the caloric, eſcapes under an elaſtic form, and produces the efferveſcent motion obſerved in this experiment. Laſtly, the oxigenated muriatic acid converts metals into oxides, and diſſolves them without occaſioning effervefcence. It deſtroys vegetable colours, as it paſſes into the ſtate of common muriatic acid. All theſe experiments prove, that Scheele's dephlogiſticated muriatic acid, is a combination of this acid in a pure ſtate, with the baſe of vital air, or the oxigenous principle; and that its proper name is, *aërated or oxigenated muriatic acid*, as I have ſhown in my firſt edition. M. Berthollet has not yet determined what quantity of oxigene the muriatic acid muſt abſorb, in order to acquire the properties of oxigenated muriatic acid*. In March 1787, he diſcovered that oxigenated muriatic gas, received into a lixiviate of cauſtic potaſh, forms a cryſtalliſable neutral ſalt, which, like nitre, or even in a greater degree, produces detonation on burning coals; affording by the action of the fire very pure vital air, or oxigenous gas, and leaving a reſidue of muriate of potaſh. Theſe experiments concur to ſupport the theory which I offered to the public ſeven years ſince, concerning the nature of the oxigenated muriatic acid; for the detonation of oxigenated muriate of potaſh is plainly owing to its containing an extraordinary quantity of oxigene. Soda forms only a deliqueſcent ſalt with the oxigenated muriatic acid.

The muriatic acid is made uſe of in ſeveral of the arts, and more eſpecially in the art of aſſaying in the humid way†. In medicine, it is well diluted in water,

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* See *Journ. de Phyſique, tome* xxvi. *page* 321, *Mai* 1785.

† See Bergman, de Docimaſia humida, Opuſc. Vol. II. Or the Engliſh tranſlation of his *Opuſcula*.—H.

ter, and adminiſtered as a diuretic, an antiſeptic, and a cooler; it is the chief ingredient of the Prior de Chabriers cure for ruptures. It is externally applied as an eſcharotic, to deſtroy altered fleſh, as a cure for the gangrene in the throat, aphthæ, &c. Mixed with a certain quantity of water, it compoſes a bath for the feet, uſed by ſome people, and conſidered as a ſecret, for drawing the gout from the more vital to the inferior parts.

But the oxigenated muriatic acid has been known for too ſhort a ſpace of time to admit of its being much uſed in the arts. M. Berthollet thinks that it may be ſucceſsfully employed for diſcovering in a few minutes or hours, what effects the action of air would produce on coloured ſtuffs, and thus determining the fixity or alterability of the colours: he has of late recommended it for whitening linen and unbleached yarn: and the firſt trials, which have been made in Paris on a pretty extenſive ſcale, promiſe favourably. It may likewiſe be advantageouſly employed for whitening in a ſhort time the yellow, and more eſpecially the green wax from our iſlands*.

Species III. *The Fluoric Acid.*

The fluoric acid, diſcovered by Scheele, has received this name becauſe it is obtained from a ſort of earthy neutral ſalt, with which we ſhall afterwards get acquainted under the name of *fluor ſpar*.

This acid when pure has a gaſeous form, and we muſt examine its properties as it exiſts in that ſtate. The fluoric acid is more ponderous than common air. It extinguiſhes lights and kill animals. It has a pungent penetrating ſmell, nearly the ſame with that of the muriatic acid gas, but rather leſs keen. Its cauſticity is ſuch that it corrodes the ſkin, however ſhort the ſpace of time during which it is expoſed to its contact. It ſuffers no ſenſible alteration from light. Heat dilates it, but without changing its nature.

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* The oxigenated muriatic acid is now generally uſed in bleaching, in conſequence of the experiments of M. Berthollet. By M. Chaptal it is recommended to make old books and manuſcripts legible. In its concrete form, it is cryſtalliſed into quadrangular priſms, truncated very obliquely, and terminated by a lozenge.—H.

The water contained in atmoſpheric air; enables it to deſtroy the tranſparency of the fluoric acid, and convert it into a white vapour; which it does more or leſs readily, according as it contains a greater or a leſs quantity of water. This phenomenon reſembles that which the muriatic acid preſents on the ſame occaſion; but the vapour of the fluoric gas is thicker than that of the other.

The fluoric acid gas unites eagerly with water, and heat is produced at the inſtant of their union. A peculiar phenomenon appears on this occaſion, namely, the precipitation of a very fine white earth, which appears to be ſiliceous earth. From this circumſtance it appears that the acid is far from being pure in the ſtate of elaſtic fluidity. It becomes pure, therefore, only when the earth, which adhered to it when it was volatilized, has been ſeparated by the action of water. A ſolution of this gas in water conſtitutes the acid ſpirit of fluor; the ſmell and cauſticity of which are very ſtrong, when the water is ſaturated with it. This liquid acid communicates a ſtrong red colour to the ſyrup of violets. According to Scheele and Bergman, it poſſeſſes the ſingular property of diſſolving ſiliceous earth. Although the fluoric acid gas, on uniting with water,

ter, depoſite a conſiderable quantity of this earth, yet it ſtill retains ſo much that alkalis cauſe it to afford a new precipitate.

Dr Prieſtley obſerved, that the fluoric acid gas corroded and penetrated common glaſs, and found it neceſſary to uſe thick glaſs bottles for his experiments. Macquer thought that the acid produced this effect only when in a gaſeous ſtate, but was incapable of attacking glaſs when liquid or diluted in water. This opinion is founded on the circumſtance of water's precipitating the ſiliceous earth, which is maintained in a ſtate of ſolution in the fluoric gas. But it is to be remembered, that the water does not entirely ſeparate the earth from the acid; and therefore the fluoric acid muſt retain, even in a fluid ſtate, the power of acting on glaſs and ſiliceous ſtones.

The liquid fluoric acid may be decompoſed like ſpirit of ſalt by heating it in a retort, the extremity of which enters a bell-glaſs full of mercury. By this means the acid is obtained in gas, and leaves the water pure.

The two French chemiſts who, in the year 1773, publiſhed, under the name of M. Boullanger, a ſeries of experiments on the vitreous ſpar, or the ſparry fluor, are of opinion that the acid of this ſpar is nothing but a combination of muriatic acid with an earthy matter, which water only is capable of ſeparating from it. But Scheele has ſucceſsfully combated this opinion. He conſiders it as a peculiar acid, ſtrikingly diſtinguiſhed from all others by the various combinations of which it is ſuſceptible. And his opinion is at preſent very generally received among chemiſts.

The fluoric is the only mineral acid capable of diſſolving ſiliceous earth. Bergman and Scheele were of opinion, in the year 1779, that this earth might very probably be a compound of the fluoric acid with water; becauſe the fluoric acid gas depoſites no ſmall quantity of ſiliceous earth, when brought into contact with water. But an experiment of M. Meyer's has ſince proved, that the earth precipitated on that occaſion comes from the glaſs veſſel, part of which is diſſolved by the acid. That chemiſt took three cylindrical tin veſſels, into each of which he put an ounce of *vitreous ſpar* and three ounces of ſulphuric acid, which having a greater affinity than the fluoric acid with lime, is ſucceſsfully employed to ſeparate this latter acid: to one of theſe mixtures he added an ounce of pulverized quartz; to the ſecond an ounce of powder of glaſs; the third he left pure without any addition: in each of the cylinders he hung a wet ſponge, and cloſing up the veſſels, expoſed them to a moderate temperature. Half an hour after, he found a ſiliceous duſt depoſited on the ſponge of the mixture containing the glaſs; at the end of twelve hours, the ſponge of the veſſel containing the quartz was likewiſe covered over with an earthy incruſtation; but even after ſeveral days the ſponge of the third veſſel exhibited no ſuch appearance. Bergman ſent an account of this experiment to M. de Morveau, letting him know at the ſame time, that he now gave up his opinion concerning the formation of ſiliceous earth by the combination of the fluoric acid gas with water. The precipitation is therefore owing to the glaſs diſſolved by the fluoric acid gas; and the acid is not pure till after the precipitate has been ſeparated from it by water and alkalis.

The fluoric acid, either in a gaſeous or a liquid ſtate, unites with aluminous earth, forming with it *aluminous fluate*[*], a ſweet taſted neutral ſalt, which readily aſſumes the conſiſtency of a thick jelly.

It combines alſo with barytes: the ſalt reſulting from this combination, to which we give the name of *barytic fluate*, is a pulverulent ſubſtance.

With magneſia the fluoric acid forms a cryſtalliſable ſalt, *magneſian fluate*.

It forms a precipitate with lime water, producing inſtantly *calcareous fluate*.

It combines with potaſh to form *fluate of potaſh*; with ſoda, it produces *fluate of ſoda*; laſtly, combining with ammoniac, it forms the ſalt which we call *ammoniacal fluate*.

This ſhort account of theſe ſaline combinations ſhows the fluoric acid to be evidently different from the muriatic. Its affinities with the different baſes afford new proofs in ſupport of the ſame truth. Bergman obſerves, that the fluoric acid, when united with potaſh, may be ſeparated from it by lime-water, which cauſes the ſolution of that ſalt to afford a precipitate. The ſame thing takes place on a ſolution of the barytic fluate, which becomes muddy when lime is put into it. Bergman gives its elective attractions in the following order; lime, barytes, magneſia, potaſh, ſoda, ammoniac: but he confeſſes that more experiments are neceſſary to eſtabliſh fully this order of affinities.

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[*] According to the methodical nomenclature which we have propoſed, the word *fluorate* is here to be uſed; but we contract it into *fluate*; and we ſhall do the ſame for the ſulphuric acid, uſing *ſulphate* inſtead of *ſulphurate*.—F.

The fluoric acid gas has not as yet been applied to any purpoſe in the arts: but its power of diſſolving ſiliceous earth, will in all probability render it very uſeful in chemical operations, when proceſſes for obtaining it more conveniently than at preſent, ſhall have been introduced.

Species IV. *The Nitric Acid.*

WHAT is called *ſpirit of nitre* in the laboratory, is a combination of this acid with water. In a liquid ſtate and pure, the acid is white; but if altered in the ſmalleſt degree, it becomes yellow or red; and there ariſes from it in great abundance a vapour of the ſame colour. It is ſo cauſtic that it burns and deſtroys inſtantaneouſly the organization of the muſcles. It reddens ſyrup of violets, and entirely deſtroys its colour.

On being expoſed to the rays of the ſun, it acquires according to Scheele, an higher colour and greater volatility; and from this it appears that light acts upon it. As it acquires a deeper colour, vital air is diſengaged from it.

Heat volatilizes this acid; and ſeparates the colouring matter in the form of red vapours.

When red, it unites eagerly with water, which aſſumes in conſequence, a green or blue colour: it appears to have acquired a conſiderable degree of heat in entering into this combination. When united with a large quantity of the fluid, it forms *aquafortis*.

The white and the red nitrous acids were formerly conſidered as being of the ſame ſubſtance, only concen-

trated

trated in different degrees; the higher coloured was thought to be the moſt concentrated of the two. But we are now better acquainted with the nature of this ſaline ſubſtance, and know it to be capable of exiſting in two different ſtates. In one of theſe the acid of nitre is deſtitute of colour, more ponderous, and leſs volatile, and emits only a white ſmoke; in the other, it is of a colour varying in ſhade from a yellow to a brown red, is more light and volatile, and is conſtantly emitting red vapours, in greater or leſs abundance, according to the temperature to which it is expoſed. Bergman diſtinguiſhes between theſe two ſtates of the acid of nitre, by giving to the one the name of *dephlogiſticated*, to the other that of *phlogiſticated;* we give to the former, the white, the name of the *nitric acid;* to the coloured, the name of the *nitrous acid.* The cauſe of theſe diſtinctions will hereafter be ſhown: Only, we may here obſerve, that if the coloured and fuming nitrous acid be diſtilled in a glaſs retort, the red part goes firſt off in vapour, and what remains is a white and colourleſs acid. The darker the colour of the ſpirit of nitre ſubjected to diſtillation, ſo much the greater is the quantity of the vapours obtained, and ſo much the leſs the portion of the white acid remaining in the retort; and *vice verſa*, when the nitrous acid heated in the retort is of a bright red colour, very little vapour, but a great deal of the white acid is obtained. This inſtance ſhows the red acid to be more volatile than the white. And as all coloured ſpirit of nitre is compounded of the two, they are to be ſeparated by a proceſs of diſtillation judiciouſly conducted. In this operation a certain quantity of vital air is always diſengaged,

ged, which may be collected by applying a pneumato-chemical machine to a balloon. We muſt remark, that when the veſſels are red-hot, certain red vapours are conſtantly ſeparated even from the whiteſt nitric acid; and the colour of the acid is alſo changed, ſo that it becomes of a flame-red: But the change produced by heat immediately diſappears when the acid returns to its former temperature, and the vapour alſo returns to a liquid. The ſame thing happens when a portion of the nitrous acid, highly coloured, is united with water; a red vapour is diſengaged and paſſes into the atmoſphere; the heat which then takes place, increaſes the colour of the acid which had been weakened by the water; what remains after the evaporation is not nitrous, but nitric acid; and the change is inſtantaneous. When heat, by the aſſiſtance of light, produces this change on the nitric acid, a quantity of vital air or oxigenous gas is diſengaged, proportioned to that of the nitrous gas which is formed on the occaſion. This decompoſition of the nitric acid, and the change of it into the nitrous, takes place in conſequence of the mutual affinities between light, caloric, and oxigene. In this inſtance the glowing heat of our veſſels acts like that of the rays of the ſun.

The nitric acid acts not upon ſiliceous earth: it combines with alumines, with barytes, with magneſia, with and with lime, the three alkalis: with theſe ſubſtances it forms the aluminous, barytic, magneſian, and calcareous nitrates, nitrate of potaſh, nitrate of ſoda, and ammoniacal nitrate. All theſe ſalts ſhall be hereafter particularly examined. The ſalts formed by the union of the ſame baſes with the nitrous acid are ſomewhat different from theſe, and are diſtinguiſhed in our methodical nomenclature by the name of *nitrites*.

The nitric unites with the carbonic acid, abſorbing it eagerly. The mutual action of theſe two bodies is not yet well known.

The nitric enters very rapidly into combination with the muriatic acid. The alchemiſts gave the name of *aqua regia* to this compound, becauſe they uſed it to diſſolve gold, the king of metals: we ſhall henceforth call it the *nitro-muriatic acid.* It muſt have always appeared ſingular, that two acids, neither of which is by itſelf capable of acting upon gold, ſhould by combination acquire the power of diſſolving it. The alchemiſts, content with having found a ſolvent for that precious metal, gave themſelves no concern about the cauſe of the phenomenon. It is but a few years ſince two Swediſh chemiſts, Scheele and Bergman, firſt ſought to diſcover what alterations the nitric and the muriatic acids produced on each other by mutual combination. Scheele obſerved, what we have already taken notice of, that by diſtilling a portion of muriatic acid on calx or oxide of manganeſe, the acid was cauſed to diffuſe a yellowiſh vapour of the ſame ſmell with *aqua regia*, which deſtroyed blue vegetable colours, and acted with a powerful force upon metals,—more eſpecially upon gold, which it diſſolved as well as the nitro-muriatic acid. He thought that it acquired theſe properties in conſequence of being deprived of its phlogiſton by the oxide of manganeſe, and that what cauſed it to act ſo forcibly on combuſtible bodies was its eagerneſs to regain the principle which it had loſt. For this reaſon he gave it the name of *dephlogiſticated marine acid.* Our firſt obſervation here is, that this explanation of theſe phenomena is directly contradictory to the theory of Stahl, which Scheele in general appears to have adopted and extended: for the muriatic acid is ſaid to acquire, by the loſs of its phlogiſton, a ſet of properties which Stahl attributed to the preſence of that principle; namely volatility, a ſtrong ſmell, and a power of acting on inflammable matters. Beſides, we are of opinion, that all theſe phenomena may be much more ſatisfactorily explained by the new theory: and this we ſhall very ſoon ſhow.

Bergman thinks that the nitric acid ſeizing on the phlogiſton of the muriatic acid, is partly diſſipated into vapour, and that what remains of the muriatic acid is then preciſely in the ſame ſtate with the vapour which ariſes from the diſtillation of this acid on oxide of manganeſe. Thus, what enables the nitro-muriatic acid to diſſolve gold, is its containing a portion of *dephlogiſticated marine acid:* and this mixed acid is often nothing but marine acid. Such is the opinion of the celebrated chemiſt of Upſal. The following appears to me a better account of the facts. When a quantity of nitric acid is poured upon a quantity of muriatic acid, heat is excited between the two liquors, and they aſſume a colour; an efferveſcence takes place, and a kind of mixed ſmell ariſes, not ſo pungent as that of the muriatic acid, but quite peculiar, and reſembling that which this acid affords when diſtilled on oxide of manganeſe. Mr Berthollet has diſcovered, that a portion of oxigenated muriatic acid is diſengaged during this rapid re-action of the two acids.

On this occaſion, therefore, the muriatic acid deprives the nitric of part of its oxigene; and is diſſipated in the form of oxigenated muriatic gas; yet a portion of it ſtill remains ſaturated with oxigene and nitrous gas; and this mixture is *aqua regia*. From this we underſtand why ſo ſmall a proportion of the nitric acid is neceſſary to communicate to the muriatic the properties of aqua regia; and why both the nitro-muriate of gold, and the nitro-muriatic acid, afford when diſtilled nothing but muriatic acid. But we muſt obſerve, that, as much more nitric acid than is neceſſary, is generally uſed to ſuper-ſaturate the muriatic acid with oxigene, the nitro-muriatic acid which reſults from this compoſition contains both acids, and they act each according to its peculiar nature, forming peculiar and diſtinct ſalts with all the bodies expoſed to their action. It would therefore be a ſervice of ſome importance to chemiſtry, to determine what quantity of the nitric acid is neceſſary to ſaturate a given quantity of the muriatic with oxigene, and to cauſe it to aſſume the character of nitro-muriatic acid, without containing any aquafortis, which only alters it and renders its effects uncertain." Hence it appears neceſſary, in recording accurate chemical experiments upon this matter, to mention the proportion in which the two acids have been mixed to produce the *aqua regia* made uſe of."

This mixed acid has leſs ſpecific gravity than either of the two acids of which it is compoſed. It has a peculiar ſmell, commonly a citron-colour, often inclining to orange. Its action on natural bodies diſtinguiſhes it from all other acids. Light extricates from it a portion of oxigene gas or vital air. Heat ſeparates from it oxigenated muriatic acid. *Aqua regia* combines with water in any proportion, and always excites heat as it enters into combination with that fluid. It diſſolves alumine, but very ſlowly: it unites with barytes, magneſia, lime, and the alkalis; and from theſe combinations there reſult mixed ſalts, which cryſtallize either ſeparately or together, according as they are more or leſs ſoluble. *Aqua regia* is much uſed both in chemiſtry and in the art of aſſaying; as we ſhall ſhow more at large when we come to ſpeak of metallic ſubſtances.

Since the æra of Dr Prieſtley's diſcoveries, chemiſts have laboured much to diſcover the intimate nature and the component principles of the nitric acid. It was ſhown, in the firſt place, that the opinion which aſcribed the formation of the nitric to the ſulphuric acid, and repreſented the former as a modification of the latter, was founded on fallacious experiments. Soon after, it was obſerved, that this acid is formed of peculiar principles; and the following obſervations led to a certain diſcovery of its nature.

The nitric acid had been long obſerved to act with great force on combuſtible bodies, more eſpecially on the metals. On ſuch occaſions, it exhales into the atmoſphere a conſiderable quantity of red vapours, and is often indeed entirely diſſipated under this form. The combuſtible body expoſed to its action is ſoon reduced to the ſtate of a burnt body, or oxide; nay, it often cauſes combuſtible bodies, ſuch as oils, charcoal, ſulphur, phoſphorus, and ſeveral of the metals, to emit a ſudden flame. Stahl aſcribed this effect to the rapidity with which the acid combined with the phlogiſtion of combuſtible bodies. But this theory did not afford a ſatisfactory explanation of the phenomenon.

Dr Prieſtley, by receiving into a glaſs veſſel filled with water, the vapour diſengaged during the action of the nitric acid on a piece of iron, obſerved, that inſtead of a red vaporous fluid, a tranſparent colourleſs gas reſembling air was obtained on that occaſion; and to this he gave the name of *nitrous gas.*

This gas poſſeſſes all the apparent properties of air, but differs greatly from it in reſpect to chemical properties. It has rather leſs gravity, is unfit for maintaining either combuſtion or reſpiration, is ſtrongly antiſeptic, has no ſenſible taſte, and takes a long time to alter the colour of ſyrup of violets. Nitrous gas appears to ſuffer no alteration from light. Heat dilates it. Vital air readily combines with it; thus reducing it to the ſtate of nitrous acid. Atmoſpheric air produces the ſame effect upon it, but not ſo forcibly. This combination diſplays ſeveral phenomena which well merit our attention. As ſoon as air comes into contact with nitrous gas, though both the fluids were before colourleſs, they become inſtantly red like the nitrous acid: a pretty lively heat is then excited; the water riſing in the receiver abſorbs all theſe red vapours, and thus acquires the character of aquafortis. The purer the air is, the more readily do theſe phenomena take place, the more ſtriking do they appear, and the ſmaller is the proportion neceſſary to change a given quantity of nitrous gas into nitrous acid. M. Lavoiſier has diſcovered, that ſixteen parts of atmoſpheric air are neceſſary to ſaturate ſeven and one-third of nitrous gas, while four parts of vital air are ſufficient for the complete ſaturation of the ſame quantity of the ſame gas. Macquer thought this beautiful phenomenon preciſely ſimilar to combuſtion. It is in fact accompanied with heat, the abſorption of air, and the production of a ſaline matter; and the red colour which then appears may be conſidered as a kind of flame.

As in this artificial compoſition of the nitrous acid, the air produces different effects, according as it is more or leſs pure, Dr Prieſtley thinks that nitrous gas may ſerve as a teſt to enable us to diſtinguiſh what quantity of vital air any other kind of air contains; if we aſſume as two terms,—the moſt impure air, or gas unfit for reſpiration, ſuch as the carbonic acid, which produces no change whatever on nitrous gas,—and vital air, which produces the greateſt alteration upon it. This aſſay conſiſts in employing known and proportional quantities of theſe two gaſes, and obſerving when they are mutually and completely ſaturated. That air is the pureſt of which the ſmalleſt quantity is ſufficient to ſaturate a given quantity of the nitrous acid, and *vice verſa*.

Several philoſophers have endeavoured to find means for performing this experiment with the moſt rigid accuracy. The Abbé Fontana has been the moſt ſucceſsful: he has contrived an *eudiometer*, of which an exact deſcription is to be found in M. Ingenhouſze's experiments on vegetables. By means of that inſtrument, the degrees of the purity or impurity of the air may be eſtimated with the utmoſt nicety; but, as the author himſelf acknowledges, ſuch ſkill and attention are neceſſary in making uſe of it, that to avoid miſtakes and erroneous calculations is exceedingly difficult.

It is farther of conſequence to obſerve, that theſe experiments, though extremely ingenious and of conſiderable utility, have not been attended with all the advantages expected from them, in regard to that branch of medicine, the object of which is the preſervation of health. They ſhow what quantity of air fit for reſpiration is contained in that under examination; but they afford no information concerning the manner in which the noxious qualities of this fluid affect the ſeveral parts of the human ſyſtem with which it is brought into contact by reſpiration: they explain not how it acts on the ſtomach, the ſkin, or the nerves; all of which are affected by almoſt every alteration of the air, though only medical obſervations can inform us in manner.

Chemiſts have for a number of years been divided in their opinions concerning the cauſe of the production of the nitrous acid from the mixture of nitrous gas with vital air. Dr Prieſtley, the diſcoverer of the fact, is of opinion, that nitrous gas is merely nitrous acid ſuperſaturated with phlogiſton; and that as pure air has a greater affinity than the acid with phlogiſton, it therefore, entering into combination with it, leaves the nitrous acid in a ſtate of liberty. But this theory is far from affording a complete explanation of the phenomenon: for when the elaſtic fluids with which the experiment is performed are very pure, there is abſolutely no reſidue left; and beſides, the nitrous acid formed during the proceſs, weighs conſiderably more than the portion of nitrous gas which was made uſe of to produce it.

M. Lavoiſier imagined that this property of nitrous gas—to produce nitrous acid, when brought into contact with vital air, might lead him to a knowledge of the component principles of the acid. By combining two ounces of ſpirit of nitre of known ſtrength, with a given quantity of mercury, he obtained 196 cubic inches of nitrous gas, and 246 cubic inches of vital air. While the former gas was diſengaged, the mercury changed its form; after the vital air was diſengaged, it returned to a metallic ſtate, when it was found to have ſuffered no loſs. From theſe facts he deduced the following inferences with great accuracy of reaſoning. —1. As the mercury ſuffered no loſs during the proceſs, the formation of the elaſtic fluids cannot be aſcribed to it. 2. Theſe muſt therefore have been formed by the decompoſition of the nitrous acid. 3. The nitrous acid made uſe of on the occaſion, the gravity of which was to that of diſtilled water as 131,607 to 160,000, appears therefore to have been formed of three principles, nitrous gas, vital air, and water, united in the following proportions to the pound: nitrous gas, 1 ounce 51½ grains; of vital air, 1 ounce 7 drams 2¼ grains; and of water 13 ounces and 18 grains. 4. Nitrous gas is nitrous acid deprived of its oxigene or vital air. 5. In all proceſſes in which nitrous gas is obtained, the nitric acid is decompoſed, and its oxigene abſorbed, by the combuſtible body with which it has a greater affinity.

Yet this opinion is attended with one difficulty. M. Lavoiſier found that he could not reproduce by the reunion of theſe products the whole quantity of the acid from which they were obtained; at leaſt one half was entirely loſt: and he had much more pure air than was neceſſary for the complete ſaturation of the nitrous gas. He acknowledges himſelf unable to account for this circumſtance. Macquer imagined it to depend on the loſs of the phlogiſton, or light, which he conſidered as one of the principles of the nitric acid; this he thought might eſcape through the pores of the veſſels during the decompoſition of the acid, leaving behind part of its pure air, which being leſs ſubtle, could not make its way out with the ſame facility. We ſhall ſoon ſee this not to be the true cauſe of the phenomenon.

The portion of ſuperfluous gas which remains after the nitrous gas has been ſaturated with vital air, ſtill remained an objection againſt M. Lavoiſier's theory. And though this ſuperfluity was quite a trifle in this experiment, as $7\frac{1}{3}$d parts of nitrous gas, with 4 parts of vital air, left no more than $\frac{1}{14}$th of their total bulk; yet ſtill he was at a loſs how to account for it. Indeed he has ſince informed us, that the reſidue was much leſs when the matters made uſe of were very pure and very nicely proportioned. In ſhort, we ſhall immediately ſee that vital air and nitrous gas may be obtained ſo pure as to combine without leaving any reſidue.

No ſuch difficulty occurs in conſidering the aëriform reſidue formed by the combination of 16 parts of atmoſpheric air with $7\frac{1}{3}$d of nitrous gas; we know it to be the mephitis or gas azote contained in the atmoſpheric air. We underſtand likewiſe how the contact of water comes at length to alter nitrous gas and change it into an acid; it is by means of the air which it contains.

But even after this theory of M. Lavoiſier's, the nature of nitrous gas ſtill remained unknown; and it has ſince been explained by a fine experiment of Mr Cavendiſh's. This chemiſt put into a glaſs tube ſeven parts of vital air not obtained from the nitric acid, with three of gas azote or atmoſpheric mephitis; and by cauſing the electric ſpark to paſs through the mixture, he effected a great diminution of its bulk, and even changed it into nitric acid. The induction which he draws from theſe facts is, that the nitric acid is a combination of ſeven parts of vital air to three of gas azote; and that, when deprived of a part of the firſt of theſe principles, as happens in the ſolution of metals, &c. it paſſes into the ſtate of nitrous gas. Nitrous gas, therefore, is, in his opinion, nothing more than a combination of gas azote with a ſmaller proportion of vital air than what is requiſite to form nitrous acid. Theſe experiments, and the ingenious theory founded upon them, throw great light on the formation of the nitric acid by the putrefaction of animal matters. We know that a great quantity of gas azote is diſengaged from theſe matters when putrefying; and it is evident how neceſſary vital air is for the production of this acid, as experience ſhows it to be formed by the combination and fixation of theſe two elaſtic fluids.

It is alſo eaſy to determine the difference between the pure white acid of nitre and the coloured fuming acid to which the northern chemiſts give the name of *phlogiſticated*; or between the nitric and the nitrous acids. The laſt is found where the principles are not combined in the proportion proper for forming the pure nitric acid,—that is, when the combination conſiſts not of three parts of azote and ſeven of oxigene.

gene. But as a variety of circumſtances, and in general all *phlogiſticating* proceſſes, diminiſh the proportion of the oxigene, by waſting more or leſs of it, hence we may naturally infer, 1. That this acid is very liable to alteration, and muſt often be more or leſs coloured and fuming: 2. That in proportion as it is deprived of more or leſs of its oxigene, it may paſs through many ſtates, from that of the pureſt nitric acid, which contains the greateſt proportion of oxigene, to nitrous gas, which contains not enough to conſtitute it an acid: 3. That if nitrous gas be deprived of what oxigene remains in it, it becomes gas azote or mephitis: 4. That as the mutual adheſion of the oxigenous and azotic principles is very trifling, moſt combuſtible bodies having a greater affinity with the former than the azotic principle has; the nitric acid cannot but be decompoſed with great facility by many bodies. Theſe four remarkable particulars in the hiſtory of the acid of nitre, ſerve to explain a great many phenomena. We now underſtand, 1. That in this acid the gas azote and vital air have loſt much of their caloric, and are therefore reduced to azote and oxigene. 2. That when this acid is decompoſed by a combuſtible body, the nitrous gas then diſengaged does not require ſo much caloric to maintain it in a ſtate of elaſtic fluidity, as vital air and gas azote. 3. That theſe two fluids cannot combine when in a gaſeous ſtate. 4. That of conſequence the vital air obtained from nitrous preparations ſtrongly heated, ſuch as *red precipitate*, nitrate of lead, common nitre, &c. muſt contain a certain proportion of mephitis or azotic gas; of which gas, the reſidue, remaining after the union of the vital air with the nitrous gas, conſiſts. No ſuch reſidue is ever obſerved to remain, when the vital air made uſe of, has been obtained from the leaves of vegetables or from mangancſe. 5. That the caſe is ſometimes the ſame with nitrous gas; it may contain a portion of gas azote or mephitis: and this happens when this gas is prepared with bodies which, being very greedy of oxigene, abſorb it almoſt entirely from the nitric acid; ſuch as iron, oils, &c. 6. That the nitrous acid when coloured, and containing an exceſs of nitrous gas or of azote, or the baſe of mephitis, is in a ſtate very different from that in which the two principles are no more than mutually ſaturated; and that as the difference between theſe two ſtates of this acid is ſo very conſiderable, they ſhould therefore be diſtinguiſhed by different names. To the white acid, which, though the moſt uncommon, *is* the pureſt, we give the name of the *nitric acid*, obſerving the ſame analogy in this as in the reſt of our new denominations; and to its neutral ſalts we give the name of *nitrates.* The red again we call *the nitrous acid*, and its ſaline combinations *nitrites*. There is indeed but ſeldom occaſion to ſpeak of the laſt of theſe claſſes of neutral ſalts: for though the red and fuming, or the nitrous, be the moſt common of the two acids, it very ſeldom retains its proper character when united with alkaline baſes; the ſuperfluous quantity of the nitrous gas uſually eſcapes as the combination is taking place, and what remains is pure nitric acid.

The affinities of the nitric acid with the alkaline baſes are the ſame as thoſe of the muriatic; and Bergman arranges them in the ſame order, as follows,—

barytes, potaſh, ſoda, lime; magneſia, ammoniac, aluminous earth. According to that celebrated chemiſt, the nitrous or *phlogiſticated* acid has the ſame affinities as the pure acid of nitre. It is ſtronger than any of the preceding acids, and diſengages the carbonic, fluoric, and muriatic acids, from their baſes.

The acid of nitre, under the name of *aquafortis*, is applied to a great many purpoſes in the arts; more particularly, it is uſed to diſſolve mercury, copper, ſilver for hatters, engravers, and gilders, in aſſaying and working metals, &c. It is likewiſe uſed in ſurgery, to deſtroy warts and other little indolent uninflamed tumours. It is uſed in many pharmaceutical preparations, ſuch as *mercurial water*, *red precipitate*, *the alkaline martial tincture*, *the yellow unguent*, &c. &c. We ſhall take notice of theſe and the other uſes to which it is applied in their proper places.

Species V. *The Sulphuric Acid.*

The ſulphuric acid, which has hitherto been called the *vitriolic acid*, is a very cauſtic ſaline ſubſtance, which, when concentrated, burns and cauterizes the ſkin, reddens ſyrup of violets without deſtroying its colour, and when diluted in a large proportion of water, has a ſour, ſtiptic taſte. This acid, when pure, appears under the form of a very tranſparent oleaginous fluid, twice the ſpecific weight of diſtilled water, deſtitute of ſmell, and united with water, from which there are as yet no means known of ſeparating it. It has received the name of the *vitriolic acid*, becauſe it uſed formerly to be obtained from martial vitriol by diſtillation. At preſent it is obtained both in France and England by the complete combuſtion of ſulphur, as we ſhall explain more at large when we come to give the hiſtory of that combuſtible ſubſtance. Its nature, therefore, and the manner in which it is obtained, render it moſt proper to give it in a methodical and regular nomenclature, the name of the *ſulphuric acid.*

When highly concentrated, it is from its conſiſtency named very improperly *oil of vitriol.*

This acid is ſuſceptible of a concrete form; which it may be made to aſſume either by expoſing it to cold, as we ſhall afterwards ſee, or by combining it with various elaſtic fluids.

We know not yet, in what manner light acts on the ſulphuric acid. Some chemiſts have aſſerted, that when oil of vitriol is expoſed in cloſe veſſels to the rays of the ſun, it gradually aſſumes a colour, and there is even ſome ſulphur formed. But this fact is not altogether eſtabliſhed by proofs; nay, there is even a ſtrong probability againſt it; for we ſhall hereafter ſee, that the ſulphuric acid cannot become ſulphur without loſing its pure air or oxigene;—and it is evident that ſuch a ſeparation cannot take place in cloſe veſſels.

Stahl thought the ſulphuric acid to be diffuſed through all nature, and to be the principle of all other acids. The firſt of theſe aſſertions was founded on this fact, that linen impregnated with potaſh, and expoſed to the air, is at length converted into ſulphate of potaſh; that is, into a neutral ſalt formed by the union of this alkali with the ſulphuric acid. This aſſertion is at preſent known to be falſe; for ſuch linen contains not an atom of ſulphate of potaſh, but a good deal of carbonate of potaſh, or the combination of this alkali with the carbonic acid. With reſpect to the ſecond, nothing can be more improbable. Late experiments have ſhown that each of the acids is formed of peculiar principles; and that there is no principle common to one with another of them, but the baſe of vital air, which is common to them all.

The ſulphuric acid, when heated in a retort, ſoon loſes part of its water, is in ſome degree concentrated, and is not volatilized unleſs expoſed to a ſtrong heat. If coloured, it loſes its colour by the action of the fire, and becomes white. This *double* change which it undergoes at *one* time, is called the *concentration* and *rectification* of the acid. While it is taking place, a very odorous and penetrating gas is diſengaged, which was the colouring principle of the acid, and with which we ſhall afterwards get acquainted under the name of the *ſulphureous acid gas*. Although this proceſs appear to render the ſulphuric acid whiter and more pure, yet it muſt be carried farther when we wiſh to obtain the acid in its higheſt purity: in fact, in this ordinary concentration, we only free the acid of the water and the ſulphureous acid gas united with it, without ſeparating any of the fixed matters, by which it may likewiſe be altered: To effect this, we muſt diſtil the acid to dryneſs, by changing the receiver, after performing the firſt part of the operation: there remains then in the retort a ſmall quantity of a white reſidue, which is found to contain ſulphate of pot-aſh, and ſome other ſubſtances which are diſſolved in the acid as it is formed.

The concentrated ſulphuric acid attracts moiſture, when expoſed to the air, and loſes part of its ſtrength and cauſticity: it at the ſame time aſſumes colour, deriving it from the combuſtible matters which float in the atmoſphere, on which this acid acts with no ſmall force. It often abſorbs nearly twice its own weight of water from the atmoſphere.

The Duke d'Ayen, by a ſeries of curious experiments, performed during the violent cold in the month of January 1776, has ſhown, that this acid, when highly concentrated, may be made to freeze by expoſing it to the cold temperature of from 61° 15', to 65° 45'; but when diluted in two or four parts of water, is no longer liable to the ſame change of ſtate by cold: and that if, when frozen it be left expoſed to the air, it ſoon becomes fluid, even though the cold be more intenſe than that which cauſed it to freeze. This laſt phenomenon is owing to its abſorbing water from the atmoſphere, and to the heat produced while the two are entering into combination.

The ſulphuric acid unites with water, diſplaying, as it enters into union with it, all the phenomena of a ſudden penetration and an intimate combination. It produces at the ſame time a lively heat and a ſort of hiſſing; a peculiar fetid odour is likewiſe diſengaged. The hiſſing noiſe excited on this occaſion is owing to the diſengagement of the air contained in the water, which is ſeen to make its way out in the form of little bubbles. The taſte of the acid, when thus diluted in water, is much weaker than in its concentrated ſtate, its fluidity is much more conſiderable, and it now bears the name of *ſpirit of vitriol.* The water may be volatilized by heating it; and it may be thus reſtored by concentration to the ſtate of concentrated ſulphuric acid.

This acid acts not in any manner on ſiliceous earth or quartzoſe ſtones, nor on the ſame earth when melted with the admixture of ſmall pieces of the fixed alkalis. It combines with aluminous earth, barytes, magneſia, lime, and alkalis. In theſe combinations it forms aluminous ſulphate, or *alum;* barytic ſulphate, or *ponderous ſpar;* ſulphate of magneſia, or *Epſom ſalt;* ſulphate of lime, or *ſelenite;* ſulphate of potaſh, or *vitriolated tartar;* ſulphate of ſoda, or *Glauber ſalt;* and ammoniacal ſulphate. Its elective attractions for theſe ſalts are the ſame with thoſe of the muriatic and the nitric acids; but it adheres more firmly to theſe ſubſtances than any of the other mineral acids; and is capable of diſengaging them.

The action of the ſulphuric on the other acids has not as yet been properly examined; we know only, 1. That it abſorbs great quantities of the carbonic acid, 2. That it unites ſo readily with the muriatic acid, that when we mix the two together, heat is excited, and a great quantity of muriatic acid gas is diſengaged in white vapours. Boerhaave, in his Chemiſtry ſays, that the muriatic acid renders *oil of vitriol* concrete: perhaps this property may be found to belong to the oxigenated muriatic acid. 3. That if the pure white nitric acid be poured on a quantity of ſulphuric acid blackened by ſome combuſtible body, it deprives it of its colour, and renders it tranſparent; and when this mixture is heated, it exhales a quantity of nitrous gas. 4. That nitrous gas, when united with this acid, has the power of making it aſſume a concrete form; as will be ſhown more particularly in the article of the decompoſition of nitrate of potaſh by means of ſulphate of iron.

The manner in which the ſulphuric acid acts on combuſtible bodies, leads us to an idea of its nature and component principles. Whenever any combuſtible body, ſuch as a metal, or ſtill more a vegetable or an animal matter, is brought into contact with the concentrated ſulphuric acid, that body paſſes ſooner or later into the ſtate of a burnt matter, and the acid is decompoſed.

All matters containing oil, become black, if immerſed in ſulphuric acid concentrated and cold. The acid firſt aſſumes a brown colour, which ſoon paſſes into a black. If an inflammable ſubſtance in combuſtion, ſuch as a burning coal, be immerſed into a quantity of ſulphuric acid, the acid immediately aſſumes the ſmell and volatility of burning ſulphur; a white ſmoke ariſes from it, of a lively ſuffocating ſmell. If, in order to comprehend better what paſſes when theſe combinations take place, we bring this acid into contact with ſome combuſtible body of a more ſimple character than organic ſubſtances, whoſe alterations may be more eaſily traced and eſtimated, we may then attain a knowledge of the principles of the ſulphuric acid. If we heat for this purpoſe a mixture of this acid concentrated, with mercury, in a glaſs retort, the extremity of which enters a bell-glaſs filled with this metallic fluid; as ſoon as the acid is brought to boil, it emits a permanent gas of a ſtrong pungent ſmell, reſembling that of burning ſulphur.

The aëriform fluid is known by the name of *ſulphureous acid gas* : it is ſomewhat more ponderous than air ; it extinguiſhes light, kills animals, reddens and diſcolours ſyrup of violets. According to Dr Prieſtley, it enters into combination with water with leſs rapidity than the muriatic acid gas ; it diſſolves chalk, camphor, and iron ; coals, and all bodies that are porous in any conſiderable degree, abſorb it. Though it has been conſidered as a permanent gas, yet by the application of an intenſe cold, it may be condenſed ſo as to become liquid, M. Monge accompliſhed this.

The ſulphureous is a certain modification of the ſulphuric acid, which combines with the alkalis to form neutral ſalts different from thoſe which they form with the latter. Stahl, who had obſerved all of theſe important phenomena with great attention, thought, that in this inſtance the phlogiſton of the metal, uniting with the acid, communicated to it odour, volatility, &c. But as that great chemiſt did not carry his experiments far enough, he could not foreſee, that a ſtrong objection againſt this doctrine might be drawn from the very fact on which it was founded. M. Lavoiſier, M. Bucquet, and myſelf, have each of us examined the conſequences of this reciprocal action of mercury and the ſulphuric acid. When the mixture is white and dry, but a very ſmall quantity of ſulphureous acid gas is formed ; if this mercurial ſulphate be then ſtrongly heated, a little water, and a gas quite different in nature from the former, are diſengaged ; the gas is very pure vital air. While this gas eſcapes from the mixture, the mercury is gradually *reduced*, and regains all its original properties, not ſo much as an eighth part of its quantity being loſt. From this it appears, that as the mercury has ſuffered no alteration, the two gaſes muſt belong both to the ſulphuric acid which has been decompoſed. The ſulphureous acid gas appears therefore to bear the ſame relation to this acid which the nitrous bears to the nitric acid. Yet the compoſition of theſe two acids is not made quite in the ſame manner; for we cannot inſtantly re-unite the two gaſeous principles of the ſulphuric acid into the compound body from which they are obtained; whereas we can form the nitrous acid at pleaſure, by combining the nitrous gas, and the vital air which it affords when analyſed. It is very likely that a conſiderable ſpace of time is neceſſary for the recompoſition of the ſulphuric acid: for this phenomenon actually takes place when we expoſe to the air compounds of the ſulphureous acid with different baſes, theſe being at length found to contain ſulphuric acid. Thus the combination of the ſulphureous acid with potaſh, known under the name of *Stahl's ſulphureous ſalt*, or ſulphite of potaſh, if expoſed to the air, becomes at the end of a certain time genuine ſulphate of potaſh. What, in theſe inſtances, is ſlowly effected, takes place with more rapidity in the combuſtion of ſulphur; during which that combuſtible body abſorbs the oxigene of the atmoſphere, and becomes gradually more and more acid, till it be completely ſaturated. (See the *Hiſtory of Sulphur.*)

From theſe facts it appears, 1. That the ſulphuric acid is a compound of ſulphur and oxigene. 2. That when a combuſtible body having a greater affinity than ſulphur with oxigene or the baſe of vital air, is mixed with it, that body decompoſes the acid, by abſorbing the oxigene. 3. That when the combuſtible matter does not carry off all the acidifying principle, as happens in moſt of the ſolutions of metals effected by the ſulphuric acid, what is ſeparated is not pure ſulphur, but ſulphureous acid gas. 4. That this gas is a kind of intermediate body between ſulphur and the ſulphuric acid; and is to be conſidered as differing from the acid, only by containing a ſmaller proportion of oxigene; from ſulphur, only by containing ſo much oxigene as renders it faintly acid. To cauſe it to paſs into the ſtate of real ſulphur, all that we need to do is, to drive off that portion of the baſe of vital air which it contains; as happens towards the end of the proceſs in which metals are diſſolved by the ſulphuric acid, when theſe ſolutions are ſtrongly heated and made to evaporate. We now likewiſe underſtand how the ſulphureous is gradually converted into the ſulphuric acid, by abſorbing the oxigene of vital air contained in the atmoſphere.

The ſulphureous acid gas is capable of uniting in a very intimate manner with the ſulphuric acid, and it then communicates to this acid the property of exhaling in thick white vapours. Meyer, in his Chemical Eſſays, on the article of Quick lime, mentions a *fuming oil of vitriol*, prepared at Northaauſen in Saxony, from a diſtillation of *common vitriol.* He likewiſe follows Chriſtian Bernhard, a German chemiſt, in mentioning a concrete fuming acid ſalt obtained from this acid by diſtillation. Finding an opportunity of procuring in Paris a conſiderable quantity of this ſulphuric acid of Saxony, I obſerved it to poſſeſs the properties aſcribed to it by Meyer, and obtained from it, by uſing a gentle heat,

cryſtallized,

cryſtallized, concrete, volatile ſalt, fuming and deliqueſcent, under two different forms, according to Chriſtian Bernhard's account of it. I am convinced, from various experiments related in a memoir of mine, read in the Royal Academy of Sciences in the year 1785. 1. That the property poſſeſſed by this black ſulphuric acid of Northaauſen, of fuming and affording a concrete volatile ſalt, depends on its containing a great quantity of ſulphureous gas. 2. That in proportion as it loſes this gas by being expoſed to the air, it ceaſes to exhale vapours, and loſes its power of affording concrete ſalt. 3. That water diſengages this gas, and deprives the ſulphuric acid of Saxony of its property of fuming, &c. 4. Laſtly, That the fuming concrete acid ſalt obtained from this acid by diſtillation is a ſaturated combination of ſulphuric acid with ſulphureous gas, which when expoſed to the air, gradually paſſes into the ſtate of common ſulphuric acid. We are therefore acquainted with two concrete ſulphuric acids, one of which owes its concretion to nitrous gas, the other to ſulphureous acid gas. I make no doubt but the number of concrete acids may be one day increaſed, by ſome other modifications of of the ſulphuric acid reduced to ſolidity by other gaſes; ſuch as oxigenated muriatic gas, &c.

The ſulphuric acid is made uſe of in many of the arts, more eſpecially by the dyer and the hat-maker, &c. It is one of the moſt common and uſeful menſtruums in the laboratory. In medicine it is externally applied as a very uſeful cauſtic, and internally as a refreſhing, cooling, and antiſeptic medicine; but in this caſe, it muſt be diluted in water till it have ſcarce any ſenſible acidity.

The ſulphureous acid is uſed in dyeing, for whitening ſilks, taking out ſtains, &c.

As theſe two acids are combinations of ſulphur and oxigene in different proportions, their names ought to be analogous to their nature: to us they appear to be beſt diſtinguiſhed by the names of the *ſulphuric acid*, and the *ſulphureous acid*. The termination of the word *ſulphureous*, ſerves in this, as well as in other inſtances, to ſhow that the acid to which it belongs contains an exceſs of the combuſtible baſe *.

Species VI. *The Boracic Acid.*

Experiments made by a great many chemiſts have ſhown borax to be a neutral ſalt formed by the combination of ſoda with a peculiar acid: this acid was called by Homberg, its diſcoverer, *ſedative ſalt*. It has been ſince named the *acid of borax*, and the *boracine acid*; we chooſe rather to call it the *boracic acid*, in order that its name may terminate in the ſame way as the names of the other acids.

Many chemiſts have thought this acid to be merely a product of art formed by the combination of the ſalts uſed in obtaining it with ſome principle of borax: But ſince M. Hoefer, apothecary to the Grand Duke of Tuſcany, has diſcovered that the waters of ſeveral lakes in that country, for inſtance, thoſe of Caſtelnuovo and Monte-rotondo, maintain in ſolution a conſiderable quantity of very pure boracic acid; we can no longer entertain a doubt of its being a peculiar acid. The chemiſts of the academy of Dijon have confirmed this diſcovery; on examining a quantity of water from the lake Monterotondo ſent them out of Tuſcany, they found it to contain the ſalt which M. Hoefer had aſcribed to it. It is very likely that the ſame ſalt may be found in other mineral waters: it appears, as we ſhall hereafter mention, to be formed by the putrefaction of fat bodies.

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* The ſulphuric acid is found, diſengaged, in nature, in ſome parts of Italy. Baldaſſari has obſerved it, in this ſtate, in a grotto in Tuſcany, at St. Albino, and at the lakes of Travale. Vandelli relates that ſulphuric acid is ſometimes found diſſolved in water, in the environs of Sienna and Viterbo. M. Dolomieu found it in pure cryſtals in a grotto on Mount Etna.—H.

The boracic acid, whether native or obtained from borax, by proceſſes which we ſhall have occaſion to deſcribe under the article of that neutral ſalt, is a concrete matter, cryſtallized in ſmall white ſcales, very thin, irregularly formed, figured round their edges, extremely light, and ſometimes glittering. It has a weak, yet a ſenſibly acid taſte. It communicates a faint red to tincture of violets; but has a much ſtronger effect on that of turnſol, mallows, raddiſhes, &c.

When expoſed to heat, it is not volatilized; but it melts when made red hot into a tranſparent glaſs; and the glaſs becomes opaque, and is covered with a light white duſt when expoſed to the air. This glaſs is the boracic acid unaltered; it regains its lamellated form when diſſolved in water, and cauſed to cryſtallize.

The boracic acid ſuffers no ſenſible alteration from the action of the air, whether it be dry, or moiſt, hot or cold.

It diſſolves in water, not without difficulty; for, according to the academicians of Dijon, a pound of boiling water diſſolves no more than 183 grains of this acid; when cooled and partly evaporated, it returns to its cryſtalline form. This ſolution inſtantaneouſly reddens the tincture of turnſol, and alters, though more ſlowly indeed, the colour of ſyrup of violets. When a quantity of the boracic acid, moiſtened with a little water, is heated in a cucurbite, fitted with a capital, part of the acid is ſublimated together with the vapour ariſing from the water; but as ſoon as the whole of the water is volatilized and the boracic acid left dry, the ſublimation ceaſes: from which it appears that the acid is of itſelf fixed, as may be ſhown by melting it in a crucible. By ſublimating it in this manner with water, if the proceſs be ſkilfully conducted, it is obtained under a beautiful ſparkling cryſtalline form. The boracic acid, after paſſing through this proceſs, is very pure, and is known in pharmacy by the name of *ſublimated ſedative ſalt.*

The boracic acid ſerves as a flux to ſiliceous earth; and the glaſs which they form together is white or faintly coloured. With the help of heat, it diſſolves the earth precipitated from the liquor of flints. It unites with barytes, magneſia, lime, and alkalis; and forms by its union with theſe ſubſtances a claſs of peculiar ſalts, diſtinguiſhed by the general name of *borates*, of which we are well acquainted with none but one ſpecies.

The whole of theſe properties, but more eſpecially its taſte, and the red colour which it communicates to blue vegetable tinctures, ſufficiently diſtinguiſh it as an acid. But it ſaturates alkaline baſes only in part; and is known to be the weakeſt of all acids, as all of the others, not even the carbonic acid excepted, diſengage it from the ſubſtances with which it combines.

The action of the other acids on the boracic is not well known. It appears to effect a partial decompoſition of the ſulphuric acid; for when diſtilled on this ſalt, the ſulphuric paſſes into the ſtate of ſulphureous acid. As to the nitric and the muriatic acids we know that they diſſolve it; but the phenomena which take place on that occaſion have not yet been ſufficiently attended to, to enable us to determine whether or not a mutual decompoſition then takes place.

A diverſity of opinions prevails concerning the nature and the formation of the boracic acid. A number of chemiſts have believed it to be an intimate combination of the ſulphuric acid, and vitrifiable earth with a fat matter. Meſſrs Bourdelin and Cadet think it to be formed by the muriatic acid. The latter of theſe two gentlemen thinks that it muſt contain a ſmall quantity of earth of copper, becauſe it has the ſame property with the oxides of copper, of communicating a green colour to the flame of combuſtible bodies. Cartheuſer aſſures us, that on drying and calcining by the action of a ſlow fire, a quantity of the boracic acid in a ſtate of great purity, he obſerved it to emit vapours of the muriatic acid; and that on diſſolving this ſalt thus dried, and filtrating the ſolution, he found a grey earth remaining after the filtration; and laſtly, that by many repetitions of this calcination and ſolution, he at length accompliſhed the entire decompoſition of the boracic acid, and found it to be a modification of the muriatic acid fixed by an earth. This experiment has been repeated by Meſſrs Macquer and Poulletier de la Salle; they obſerved an odorous vapour to be diſengaged during the calcination of this ſalt; but they were not able to diſtinguiſh from its ſmell that it was muriatic acid.. By repeated deſiccations and ſolutions, they obtained a ſmall portion of grey earth; but the earth, when united with the muriatic acid, did not form ſedative ſalt, as Cartheuſer had given out; and of conſequence this chemiſt's opinion appears to be no better ſupported than the reſt. Model thought this ſalt to be a combination of a peculiar alkali with the ſulphuric acid, which is uſed in diſengaging it. But this opinion cannot be admitted; for the boracic acid is always the ſame, whatever be the acid uſed to precipitate it. M. Baumé ſays, that he found means to produce the boracic acid by leaving a mixture of greaſe and clay to macerate for 18 months. At the end of that time, he obtained from it, by lixiviation, a ſalt in ſmall ſcales, with all the properties of *ſedative ſalt.* From this he concludes the boracic acid to be a combination of the acid of greaſe with a very fine earth, which it is impoſſible to ſeparate entirely from it. He adds, that the ſame ſalt may be produced with vegetable oils, but more ſlowly. M. Wiegleb repeated M. Baumé's experiment, but without obtaining boracic acid.

Chemiſts at preſent think this to be a peculiar acid differing from all others, and poſſeſſing certain characteriſtics of its own. Its elective attractions for alkaline baſes are arranged by Bergman in the following order; lime, barytes, magneſia, potaſh, ſoda, ammoniac. As they differ greatly from thoſe of the other acids above-examined, they afford an additional proof of the peculiarity of the nature of this acid, whoſe component principles remain ſtill unknown.

The uſe of the boracic acid in medicine, was firſt introduced by Homberg, who aſcribed to it quieting narcotic qualities, and gave it the name of *ſedative ſalt*, or *volatile narcotic ſalt of vitriol*, becauſe he had obtained it by ſublimating a mixture of *nitre* and *vitriol*, But experience has ſince ſhown the medical virtues of this ſalt to be but very moderate; at leaſt it muſt be given in a much ſtronger doſe than Homberg has directed, in order to produce the effects he aſcribes to it; and it is very properly rejected, as we have many other medicines of the ſame claſs, whoſe effects are much more certain.

It is uſed in many operations of chemiſtry, and in the aſſaying metals as a flux. We will ſpeak of its application to this purpoſe in a ſubſequent chapter*.

CHAP.

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* The water of the lake Cherchiajo, near Monterotondo, in the Lower Sienneſe, afforded to M. Hoefer, three ounces of pure acid of borax, out of an hundred and twenty pounds of the water: 12,280 grains of the water of the Lake of Caſtelnuovo, afforded 120 grains of pure boracic acid. Some pure boracic acid was collected in the mines of Tuſcany by M. Beſſon. Mr Weſtrumb found borax in the *cubic* quartz of Limeburg —H.

CHAP. V.

ORDER II. SECONDARY, *or* NEUTRAL SALTS.

UNDER the name of *ſecondary ſalts*, are comprehended all ſuch ſubſtances as are formed by the combination of two primary ſaline matters. They have received the name of *neutral ſalts*, becauſe they poſſeſs not the characteriſtics of primary ſalts; that is, they are neither acid nor alkaline. Yet ſeveral of them, ſuch as borax, chalk, and alkalis when united with the carbonic acid, exhibit, though in an inferior degree, ſome of the properties of primary ſalts. Theſe ſecondary ſalts have not ſo ſtrong a taſte as moſt of the primary; nor do they diſſolve, or enter into new combinations ſo readily. But, what principally diſtinguiſhes them from the primary is, their inability to communicate ſaline properties to other bodies. Their cryſtalline form is another characteriſtic by which they are diſtinguiſhed; it merits the attention of the naturaliſt; but, though it ſometimes determines their nature, it alſo occaſions frequent miſtakes.

The term *baſe*, is commonly uſed to denote the more fixed part of the compoſition of neutral ſalts. As this baſis, which is ſometimes volatile, communicates ſeveral pretty uniform general characteriſtics to the various combinations with acids, of which it admits, we ſhall uſe the name of the *baſe*, to diſtinguiſh the genera of ſecondary ſalts. Theſe ſalts may then be divided into ſo many genera as there are ſaline or alkaline baſes capable of being united with acids.

The firſt genus comprehends all ſuch as are formed by the union of the two fixed alkalis with any of the acids. Theſe we ſhall denominate *perfect neutral ſalts;* becauſe the union of their component parts is very intimate.

The ſecond genus includes thoſe ſalts which are formed by the combination of volatile alkali, or ammoniac with acids. They have received the name of *ammoniacal ſalts* from the modern name of their baſe. They may alſo be called *imperfect ſalts*, becauſe they are much eaſier decompoſed than thoſe of the former genus.

In the third genus are ranked ſuch as have lime for their baſe. Theſe are in general more imperfect than thoſe of the ſecond genus, although lime has a ſtronger affinity than ammoniac with the acids, as will be afterwards particularly ſhown. They are denominated *calcareous neutral ſalts.*

The fourth genus conſiſts of combinations of magneſia with various acids. Theſe ſalts are ſtill more eaſily decompoſed than thoſe of the laſt mentioned genus; becauſe acids have a ſtronger affinity with lime and alkalis than with magneſia. Their proper name is *magneſian neutral ſalts, or neutral ſalts with a baſe of magneſia.*

To the fifth genus belong thoſe of which the baſe is pure argillaceous or aluminous earth. Alum being the chief of theſe combinations, they have received the generic name of *aluminous ſalts.* Aluminous neutral ſalts are almoſt always decompoſed by the operation of alkalis, lime, and magneſia.

Laſtly, To the ſixth genus we aſſign neutral ſalts, having a baſe of barytes or ponderous earth. Both theſe and the greater part of the two preceding genera are but very little known. *Barytic ſalts* is the diſtinctive name of this genus.

It may be eaſily imagined, that theſe ſeveral baſes, when combined with the acids whoſe properties we have examined, muſt afford a very conſiderable number of neutral ſalts: and this number will be much more conſiderable, if, with Bergman, we admit as diſtinct ſalts the various combinations of theſe ſame baſes with thoſe acids which he calls *phlogiſticated;* and which, according to the modern doctrine, are deprived of a part of their pure air or oxigene. But as theſe compounds are liable to alterations on coming into contact with air, which cauſes them almoſt inſtantly to aſſume the character of real neutral ſalts, it ſeems improper to add them to a liſt which is already but too numerous; we ſhall, however, point out what peculiar properties they acquire from the ſtate of their acids. We muſt obſerve farther, that although the alkaline baſes here enumerated, when combined with aqua regia, afford a mixture of nitrous and marine ſalts, yet as theſe may be obtained ſeparate, and are perfectly the ſame with thoſe produced by the ſimple acids; we mean, therefore, to take notice of them only when ſpeaking of the combination of alkaline baſes with the ſimple acids. Having hitherto examined no more than ſix principal acids, we are to treat only of the neutral ſaline combinations into which theſe enter.

In the arrangement of the ſeveral ſpecies of the neutral ſalts, the moſt natural order ſeems to be that of the affinities of the acids: and, therefore, through all the genera, we begin with ſulphatic ſalts, proceeding from them to the nitric; after which we treat ſucceſſively of thoſe whoſe baſes are combined with the marine, the boracic, the fluoric, and the carbonic acids, the laſt of which is the weakeſt of all.

That our nomenclature may be clearly expreſſive of the nature of the ſubſtances to which it refers, the name which we affix to each of theſe ſalts is compounded of the name of its acid and that of its baſe; and the various names by which any neutral ſalt has been known at different periods are carefully ſubjoined.

Genus I. *Perfect Neutral Salts,* or *Salts with a baſe of fixed Alkali.*

Species I. *Sulphate of Potaſh.*

Sulphate of potaſh, which has been alſo called *vitriolated tartar, Sal de duobus, Polychreſt ſalt,* and *Arcanum duplicatum,* is a perfect neutral ſalt, reſulting, as its new name denotes, from the combination of the ſulphuric acid with potaſh. It ſeldom appears in the mineral kingdom; but a few vegetables contain a ſmall quantity of it.

This ſalt is generally in a greater or a leſs degree tranſparent and regular; its cryſtals differ in form and magnitude, according to the circumſtances in which they are obtained. When formed ſlowly in the ſmall way, they aſſume the figure of tranſparent ſix-ſided pyramids, nearly ſimilar to roſe-diamonds; and ſometimes, though leſs frequently, they take the form of ſix-ſided priſms, terminating in two hexahedral pyramids, much like rock cryſtal. But if the evaporation be very rapid, the cryſtals are agglutinated into one maſs, under the form of a ſolid cruſt, the ſurface of which is covered with ſmall irregular pyramidal ſpikes: of this kind is the ſalt of this name met with in commerce. Laſtly, when, in order to obtain the cryſtals as regular as poſſible, a ſolution of this ſalt is expoſed to a gentle ſpontaneous evaporation by the heat of the atmoſphere, its cryſtals are generally ſolid twelve-ſided figures, joining at the baſe, and ſometimes ſeparated by a ſhort ſix-ſided priſm. Theſe indeed are uſually foul, and at no time equal the whiteneſs and tranſparency of thoſe which are obtained by the former proceſs of evaporation. But one imperfection attending moſt of theſe neutral ſalts is, that they are either of a dark colour or an irregular figure.

Sulphate of potaſh has a very diſagreeable bitter taſte. Fire produces but little alteration upon it. When laid on burning coals, it breaks with noiſe into a number of little pieces: This phenomenon, which is called *decrepitation*, ariſes from the ſudden rarefaction of the water which entered into it when it was cryſtalliſed. But ſulphate of potaſh loſes none of its eſſential properties by decrepitation. It decrepitates in the ſame manner when expoſed to the action of fire in a crucible, and becomes dry, friable, and even pulverulent, by loſing the water which it contained: it becomes red before melting, and a ſtrong fire is requiſite to bring it to fuſion. If expoſed to cold when in a ſtate of fuſion, it becomes an opaque maſs, friable, and ſoluble: it appears likewiſe to have ſuffered no alteration of its principles; for it regains its tranſparent and cryſtalline form on being diſſolved in water. If kept for a while in the ſtate of fuſion in an open veſſel, it is volatiliſed, but without being decompoſed.

Sulphate of potaſh ſuffers no alteration from air. It remains in its cryſtalline ſtate, without ſuffering any change either of form or of tranſparency. It is ſcarce ſoluble in water; yet the difficulty of diſſolving it is greater or leſs according to the temperature of the fluid. According to Spielman, about 18 parts of cold water are required to diſſolve 1 of this ſalt. But boiling water diſſolves it nearly in the proportion of 4 to 1;

for M. Baumé aſſures us, that 4 ounces of boiling water diſſolve 7 drams and 48 grains of ſulphate of potaſh. It is cryſtalliſed partly by cooling, but ſtill more by evaporation: It contains but very little water in its cryſtals, and therefore ſuffers no change of ſtate when expoſed to the air.

Sulphate of potaſh acts not at all on the ſimple earths. When accidentally mixed with ſalts uſed as fluxes in making glaſs, it is found again in the ſcoriæ; and it is obtained in conſiderable quantities from glaſs gall.

According to Bergman, barytes or ponderous earth having more affinity than potaſh with the ſulphuric acid, decompoſes this neutral ſalt. If a ſolution of this earth be poured on a ſolution of ſulphate of potaſh, this proceſs forms a precipitate of barytic ſulphate or *ponderous ſpar*, which is abſolutely inſoluble; its properties we ſhall hereafter examine. The potaſh, if pure and cauſtic, remains diſſolved in the liquor.

Lime and magneſia act not on ſulphate of potaſh; but many of the acids act very forcibly upon it. Rouelle diſcovered that it is poſſible to combine with this ſalt a greater quantity of the ſulphuric acid than it naturally contains. His proceſs conſiſts in diſtilling a quantity of concentrated ſulphuric acid on ſulphate of potaſh. The neutral ſalt becomes impregnated with the acid, and acquires new properties: it now reddens the tincture of violets, is ſoluble in water, has a ſour taſte, and efferveſces with alkalis ſaturated with carbonic acid, even after being diſſolved and cryſtalliſed. M. Baumé has maintained, that no real combination takes place between the acid and the neutral ſalt, and that they may be ſeparated merely by placing them on bibulous paper or ſand. But Macquer remarks, that the ſulphuric acid adheres with no inconſiderable force to ſulphate of potaſh; and thinks that their mutual adheſion muſt be owing to a peculiar affinity between the two ſubſtances: according to him neither fire nor water is able to ſeparate them. I have ſeveral times combined the concentrated ſulphuric acid with ſulphate of potaſh, in Rouelle's way; that is, by diſtillation in glaſs retorts, and have obſerved ſome phenomena not mentioned in his diſſertation on the ſubject. Sulphate of potaſh melts on the occaſion into a kind of glaſs or opaque white enamel of a ſtrong acid taſte: but this vitreous frit does not attract moiſture from the air; on the contrary, it rather exhibits appearances of eﬄoreſcence, when the acid makes only a fourth part of the total weight. There is, therefore, as Macquer thought, a pretty ſtrong adheſion between the neutral ſalt and the acid; and that adheſion is no doubt owing to a peculiar combination.

M. Baumé has obſerved, that ſulphate of potaſh ſuffers a very conſiderable alteration from the nitrous acid. If aquafortis be boiled on this ſalt, the nitrous acid ſeizes on part of the potaſh, and diſengages the ſulphuric acid contained in it. When this mixture is ſuffered to cool, its cryſtals are pure nitre. It was at firſt thought that this decompoſition could not take place without the help of heat; but if fuming ſpirit of nitre be poured on ſulphate of potaſh in powder, it will be found at the end of ſome hours to have depoſited cryſtals of nitre. It was likewiſe advanced, that when the mixture became cold, the ſulphuric acid, reſuming its rights, decompoſed in its turn the nitre of potaſh: but I have kept mixtures of ſulphate of potaſh with ſpirit of nitre for ſeveral years, and at the bottom of the mixture there were always ſaline cryſtals which detonized on burning coals, and ſuffered no change of nature though immerſed in the ſulphuric acid ſeparated by the nitrous. M. Cornette has obſerved, that the concentrated muriatic acid likewiſe decompoſes ſulphate of potaſh, even cold. From theſe two facts it would appear, that the law of affinity reſpecting theſe different acids does not hold ſo invariably as was imagined. Yet we muſt obſerve, with Bergman, 1. That whatever quantity of the nitrous and muriatic acids be made uſe of in theſe experiments, no more than a third part of the given quantity of ſulphate of potaſh is ever decompoſed; while the ſulphuric acid, when applied in a moderate proportion to nitrous and muriatic ſalts, effects a total decompoſition of them: 2. That ſuch a decompoſition never takes place, except when the ſulphate of potaſh contains rather more of the ſulphuric acid than is neceſſary to conſtitute it a neutral ſalt. 3. That the affinity of ſulphate of potaſh for the ſulphuric acid, is the true cauſe of theſe decompoſitions, and that undecompoſed ſulphate of potaſh, is very acid.

But of all the modes of decompoſition to which ſulphate of potaſh is liable, the moſt worthy of our attention is that which it ſuffers from many combuſtible matters, more eſpecially from charcoal and ſeveral metallic ſubſtances (See my *Memoires de Chimie*, p. 225.). If a mixture of this ſalt with coal be ſtrongly heated in a crucible, the ſulphate of potaſh will be converted into ſulphur united with the fixed alkali. Stahl thought this a very happy experiment for demonſtrating the exiſtence of phlogiſton; modern chemiſts explain it by the pneumatic theory. In the hiſtory of ſulphur, we ſhall give both theories.

A quintal of ſulphate of potaſh in cryſtals contains, according to Bergman, about 52 parts of potaſh, 40 of ſulphuric acid, and 8 of water,—which laſt is neceſſary to make it cryſtallize.

As this ſalt is found but ſeldom in nature, and even then in ſmall quantities, the ſulphate of potaſh made uſe of in medicine is always a product of art. There are three ways of preparing it. Firſt, by a direct combination of the ſulphuric acid with potaſh. This inſtantly produces ſulphate of potaſh, which may be diſſolved in water, and cryſtallized, as we have mentioned above. The ſecond way is, decompoſing, by means of the ſulphuric acid, neutral ſalts conſiſting of potaſh united with other acids; ſuch as nitrate, muriate, and carbonate of potaſh, &c.: Sulphate of potaſh is infallibly obtained by all of theſe decompoſitions. The third way of forming this ſalt is by uſing potaſh to decompoſe earthy and metallic ſulphuric ſalts. The potaſh precipitates the ſalino-terrene ſubſtances and the metallic oxides, and ſeizes the ſulphuric acid. We will have occaſion to take farther notice of the laſt two of theſe methods of preparing ſulphate of potaſh, when we come to give an account of the neutral ſalts uſed in the preparation *.

This ſalt is not much uſed except in medicine. It is a pretty efficacious purgative. It is ſometimes given by itſelf in dozes of half an ounce or an ounce. But

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* Mr Chaptal relates, that he had occaſionally obtained ſulphate of potaſh from the analyſis of tobacco.—H.

But it is moſt generally given, a dram or two at once, together with ſome other purgative medicines. It is uſed as a ſolvent in chronical diſtempers, particularly in coagulations of milk. It is then given in doſes of a few drams together in certain preparations of liquids; but its ſolvent power is much inferior to that of many other neutral ſalts, which are more ſoluble and leſs nauſeous.

The ſulphureous acid, or the ſulphuric with an overplus of ſulphur, forms, when combined with potaſh, a ſalt ſomewhat different from that which we have been conſidering. Stahl called it *ſulphureous ſalt*; we give it the name of *ſulphite of potaſh*. This ſalt cryſtallizes in polyhædrons of ten ſides, or in two tetrahædral pyramids cut towards their baſes: it is very bitter, eaſily ſoluble, and rather deliqueſcent. Almoſt all mineral acids, and many vegetable acids, diſengage the ſulphureous acid from this ſalt with efferveſcence, and in a gaſeous form. Sulphite of potaſh, when expoſed to the air, gradually abſorbs oxigene, and is converted into ſulphate of potaſh *.

Species II. *Sulphate of Soda.*

Sulphate of ſoda, which has been hitherto known by the name of *Glauber ſalt*, from the name of the German chemiſt who firſt diſcovered it, is a perfect neutral ſalt, formed, as its name indicates, by the union of the ſulphuric acid with mineral alkali or ſoda. This ſalt poſſeſſes many properties in common with ſulphate of potaſh, and ſome peculiar to itſelf. It is equally diſpoſed to cryſtallize as the other; has a bitter taſte; is ſcarce fuſible; diſſolves in water; is incapable of union with earths; and, like ſulphate of potaſh, is decompoſable in part by the nitrous and muriatic acids. Many of its properties, however, are conſiderably different from thoſe of ſulphate of potaſh; as we ſhall ſee by examining them particularly.

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* In oppoſition to facts above related by M. Fourcroy, M. Chaptal aſſerts, that in 1780, he himſelf ſhewed that the *nitric* acid, without aſſiſtance, will diſſolve ſulphate of potaſh; but that the ſulphuric acid reſumes its place, when the ſolution is concentrated by heat.—H.

Sulphate of ſoda is commonly a body of a regular form, and more or leſs white or tranſparent. Its cryſtals are priſms with ſix unequal and ſtriated ſides terminating in dihædral ſummits. They are ſeldom under a regular form, and the number of the ſides varies as well as their ſize, poſture, and ſtriæ; as M. Romé de Lille has ſhown very particularly in his cryſtallography. The priſms of this ſalt vary in ſize from the form of ſmall needles, very minute, to priſms half an inch in diameter and ſix or eight in length; which laſt are obtained when a great quantity is cryſtallized at once. Its taſte is at firſt freſh, but ſoon becomes very diſagreeably bitter. It produces no alteration on blue vegetable colours.

When expoſed to the action of fire, it is quickly liquefied: but it ſoon dries and becomes of an opaque white colour; in which ſtate it is no leſs difficult to melt than ſulphate of potaſh. In order to form a juſt notion of what paſſes when heat acts with this effect on ſulphate of ſoda, we muſt take notice that ſaline ſubſtances are melted two ways. 1. By means of the water which enters into their cryſtals, which is called *aqueous fuſion.* This takes place only on ſuch ſalts as are more ſoluble in warm than in cold water; which happens becauſe the portion of the fluid which enters into conſtitution of their cryſtals, being then warmed, diſſolves the ſaline matter. This aqueous fuſion is therefore nothing more than ſolution by warm water: and therefore ſulphate of ſoda aſſumes again a ſolid form when it is ſuffered to cool. 2. But if the heat be continued after it is liquified, it becomes dry and white: it may then be melted by means of a more intenſe heat; and this fuſion is actually the effect of fire, and therefore called *igneous fuſion.* Sulphate of ſoda is therefore no leſs difficult of fuſion than ſulphate of potaſh; and like it is volatilized by the extreme violence of fire, but ſuffers no alteration of principles from the action of heat.

It is likewiſe on account of their containing a great quantity of water, that the cryſtals of ſulphate of ſoda when expoſed to the air, are in a ſhort time reduced to a very fine white powder. This phenomenon is called *efflôreſcence;* becauſe in fact the cryſtals are covered over with a kind of fine flour, in whiteneſs and, form reſembling the ſublimated matters which are known in chemiſtry under the improper name of *flowers.* The cauſe of this ſalt's falling down in this manner, when expoſed for ſome time to the air, is its loſing the water on which the conſtitution of its cryſtals depends. It therefore effloreſces moſt readily when the air is very dry, and of conſequence eager to abſorb moiſture. This phenomenon, therefore, bears a great reſemblance to the deſiccation effected by heat: both depend on the evaporation of the water to which the cryſtalline form is owing. Yet, as the water which enters into the cryſtals of ſulphate of ſoda, and of all efflorefcent ſalts in general, is perfectly combined with the ſaline matter; efflorefcence appears to be owing to a kind of elective attraction between air and water. This phenomenon is therefore to be conſidered as a decompoſition of cryſtals, taking place in conſequence of water's having a greater affinity with air than with the ſaline matter. Such has always been my idea of efflorefcence, and I do not ſee how it can be explained otherwiſe, (See my *Memoires de Chimie*). Sulphate of ſoda loſes almoſt half its weight when it undergoes this alteration: but its nature is not changed, and we may cauſe it to reſume its cryſtalline form, by reſtoring to it the water which it has loſt. Though no writer on the Materia Medica have as yet made the obſervation, yet to me, it ſeems an object of ſome importance, to know the exact quantity of water which ſulphate of ſoda loſes when it effloreſces, in order that the ſame quantity may be always preſcribed for a doſe, in whatever of the two ſtates the ſalt may happen to be. Rather more than one-third leſs of this ſalt ſhould be given when it is in a ſtate of efflorefcence than when it is under the form of fine tranſparent cryſtals.

Sulphate of ſoda diſſolves very eaſily in water. No more than four parts of cold water are neceſſary to diſſolve one of this ſalt. But a ſmaller quantity of warm water will be ſufficient to diſſolve the ſalt, and a ſtill ſmaller quantity in proportion as the water is made hotter. One part of boiling water diſſolves almoſt as much of this ſalt as is equal to its own weight. The method in which we make it cryſtalliſe is founded on this property. As it is more ſoluble in warm than in cold water, all that we need to do is, to leave a ſtrong ſolution of this ſalt to cool; and it affords cryſtals which are more or leſs regular, and of a greater or a ſmaller ſize, in proportion as the quantity of the ſolution is greater or leſs, and as it is cooled more ſlowly or more quickly. In the laboratories of apothecaries, where this operation is performed in the great way, ſtriated priſms ſeveral inches long are often obtained, which afford ſpecimens of the regularity of the form of this ſalt.

Sulphate of ſoda acts no more on ſilice or alumine than ſulphate of potaſh: and as it is ſo difficult of fuſion, it is no more uſed in making glaſs than the other. Barytes decompoſes it as well as ſulphate of potaſh; but the other ſalino-terrene ſubſtances produce no alteration upon it.

Pure cauſtic potaſh, mixed with a ſolution of ſulphate of ſoda, decompoſes it; becauſe it has a ſtronger affinity than ſoda with the ſulphuric acid. In order to receive full conviction of this, the reader may pour a lixiviate of cauſtic potaſh on a warm and ſtrongly ſuturated ſolution of ſulphate of ſoda. This ſolution, which, if ſuffered to cool, would have afforded cryſtals of the latter, gives ſulphate of potaſh by evaporation; and the mother water contains cauſtic ſoda.

The ſulphuric acid combines with ſulphate of ſoda, and adheres to it in the ſame manner as to ſulphate of potaſh.

The nitric and the muriatic acids decompoſe it with the ſame attendant circumſtances as when they decompoſe ſulphate of potaſh.

When ſulphate of ſoda is violently heated with charcoal and ſome metals, the ſulphuric acid aſſumes the form of ſulphur, as we ſhall have occaſion to mention under the hiſtory of that combuſtible body.

All the properties in which ſulphate of ſoda differs from ſulphate of potaſh, ſerve as ſo many proofs that the two fixed alkalis, however ſimilar in their ſtate of purity, are nevertheleſs extremely different from each other; becauſe they form very diſſimilar ſalts when combined with the ſame acid. Beſides, the proportion in which the principles of this ſalt are united, is very different from that by which ſulphate of potaſh is formed: for, according to Bergman, a quintal of ſulphate of ſoda contains 15 parts of ſoda, 27 of ſulphuric acid, and 58 of water *.

This ſalt is more copious in nature than ſulphate of potaſh. It is obtained in great abundance from ſea-water, from the water of certain ſalt ſprings, and more eſpecially from many mineral waters. Art can likewiſe procure it by the three methods of which we have given a deſcription in the hiſtory of ſulphate of potaſh. It is not more uſed in the arts than that ſalt; but much more in medicine. It is given as a ſolvent, aperient, and purgative, in doſes of—from half a dram to an ounce and an half, according to the caſes in which it is adminiſtered. Its effects are even more ſtrong and quick than thoſe of ſulphate of potaſh; becauſe its ſapidity is greater, and it diſſolves much more readily in the humours of the human body †.

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* Others aſſert, that 100 grains of ſulphate of ſoda contain 14 acid, 22 alkali, and 64 water.—H.

† The *tamarix gallica*, a plant growing on the ſea coaſt of France, contains ſulphate of ſoda in a large proportion.—H.

We are ignorant of the properties of ſulphite of ſoda, or of that ſalt which is formed by the combination of the ſulphureous acid with alkali of ſoda.

Species III. *Nitrate of Potaſh, or Common Nitre.*

Nitrate of potaſh, common nitre, or ſaltpetre, is formed by a ſaturated combination of the nitric acid with potaſh. This ſalt has a freſh taſte, is a perfect neutral ſalt, and does not alter the colour of ſyrup of violets. Its cryſtals are ſix-ſided priſms, terminating in dihedral pyramids, or cut off with a ſlope, and often channelled from one end to the other.

There is great abundance of this ſalt in nature: it is continually forming in places inhabited by animals. It is likewiſe found in abundance on walls ſheltered from rain; and is then called *ſaltpetre de houſſage.*

There ſeem to be three circumſtances which chiefly promote its formation. The firſt of theſe is the preſence of chalk, or ſome calcareous ſubſtance; in this manner is the nitre formed which is gathered on walls covered with plaſter; and from this circumſtance, conſiderable quantities of nitre are uſually found on the demolition of old buildings. This ſalt is obtained in a ſtate of perfect purity from chalky earths. The Duke de la Rochefoucault has obtained it in the proportion of an ounce to the pound from chalk of Roche-Guyon.

The ſecond circumſtance favourable to the production of ſaltpetre is the putrefaction or ſpontaneous decompoſition of animal and vegetable matters. It is a well known fact, that places watered with animal liquors, or containing animal matters in a ſtate of putrefaction, ſuch as dunghills, ſtables, jakes, afford great quantities of nitrate of potaſh. This fact has always been gone upon as a principle, in forming beds for the artificial production of nitre. Ditches or covered ſheds are formed, and left expoſed on all ſides to the air: theſe are then filled with putreſcent ſubſtances, ſuch as dung of all kinds, and vegetable ſubſtances; water containing animal or vegetable matters is from time to time poured on the maſs; and it is ſtirred now and then to change the relative diſpoſition of the ſurfaces. When the putrefaction is conſiderably advanced, a ſmall portion of the matter is taken and lixivated, in order that it may be known whether it contains nitre; and if it be found to contain a ſufficient quantity of the ſalt, the whole maſs is ſubjected to the ſame proceſs.'

The third circumſtance apparently favourable to the production of nitre, is the contact of the air. This is one great cauſe of the formation of the ſaltpetre found on walls; and it is on this principle that the mixture depoſited for the artificial production of nitre is frequently ſtirred, in order that the air may have acceſs to every part of the maſs. Beds of chalk, which naturally contain nitre, afford it only to a certain depth, and not lower. Where theſe three circumſtances meet, nitre is produced in great abundance. Beds for the artificial production of nitre ſhould be formed on theſe principles.

It is but a very ſhort time ſince the theory of the production of nitre came to be known. Glauber, and a number of chemiſts who implicitly adopted his opinion, thought this ſalt to be entirely formed in vegetable ſubſtances, in them conveyed into the bodies of animals, and by putrefaction only diſengaged into a free ſeparate ſtate: But it was ſoon obſerved, that the vegetables uſed for its production in nitre-works could not be ſufficient to afford, of themſelves, the quantities obtained. M. Thouvenel, who by his eſſay on the formation of nitre gained a prize from the Academy, made a great many experiments with a view to diſcover its cauſe, and found that the nitric acid was formed by the combination of an elaſtic fluid diſengaged from animal matters in a ſtate of putrefaction with vital air. He has alſo ſhown that this acid, when formed, combines with calcareous earth, where nothing but animal matters is uſed for nitre beds; and that the uſe of vegetable ſubſtances is to furniſh fixed alkali or potaſh, which is the baſe of common nitre. M. Thouvenel had not determined the nature of the gas which is diſengaged from animal matters in a ſtate of putrefaction. And Mr Cavendiſh has ſince ſhown it to be the ſame with that which, under the name of phlogiſticated air, atmoſpheric mephitis, or gas azote, conſtitutes one of the principles of the atmoſphere. By combining this gas with vital air, by means of the electric ſpark, he obtained a product of genuine nitric acid.

Nitrate of potaſh is very liable to alteration from heat. When expoſed to the action of fire in a crucible, it ſoon liquefies—by igneous fuſion; for though kept for ſome time in that ſtate, it does not become dry; and though made red hot, does not aſſume a pulverulent form. When ſuffered to cool, after being melted, it congeals into an opaque maſs which is named *cryſtal mineral,* and is equally ponderous, fuſible and ſoluble with nitrate of potaſh. The cryſtal mineral of the apothecaries ſhops is ſomewhat different from pure melted nitre: for it contains a little ſulphate of potaſh, produced by the combuſtion of ſulphur, which, according to the Pariſian pharmacopœia, is uſed in the proportion of a dram to the pound of nitre, in the preparation of it.

If nitrate of potaſh be left expoſed to the action of fire, after being melted, it will be of itſelf decompoſed and reduced to alkali. This operation ſucceeds equally well in a retort; and when performed in this manner, is of uſe to explain the decompoſition of the nitric acid. In fact, inſtead of the nitric acid paſſing off pure, there eſcapes a large quantity of an aëriform fluid, which may be collected under water, and is found to be genuine vital air mixed with gas azote. The reſidue of alkali uſually melts the retort very ſoon after it is ſeparated; and when we wiſh to purſue the operation to a concluſion, we muſt uſe a ſtone retort which may be proof againſt its action. Here we have the nitric acid entirely decompoſed into vital air and gas azote by means of heat, which alone is able to ſeparate theſe two principles. If the heat be not continued ſo long, or made ſo intenſe, as to effect the entire decompoſition of the nitrate of potaſh. The alkali ſtill retains a certain quantity of the nitrous acid, or of the nitric with an exceſs of nitrous gas. This acid may be diſengaged from it by vinegar. In this ſtate, the ſalt is what we call *nitrite of potaſh*, the nitrous acid being ſuperſaturated with gas azote; in the ſame manner we called the combination of the ſulphureous acid with potaſh, *ſulphite of potaſh*. If nitrate of potaſh be acted upon by a very intenſe heat, a reſidue of pure cauſtic alkali is obtained. Since heat decompoſes nitrate of potaſh with ſuch facility, it may be naturally inferred, that when cryſtal mineral is prepared by ſimple fuſion, the ſalt muſt not be too long expoſed to the fire. If this precaution be neglected, the medicine will contain more than a juſt proportion of potaſh, and will produce too violent effects.

The decompoſition of nitrate of potaſh is attended with other phenomena, when it is expoſed to the action of fire, together with combuſtible bodies. When laid on a coal it gives a white lively flame, attended with a kind of decrepitation: this is called the *detonation, or fuſion of nitre*: the ſalt is then ſaid to detonize or melt; and by this characteriſtic, nitre may be at any time eaſily diſtinguiſhed. Stahl thought this phenomenon to be owing to the rapid combination of the acid of nitre with phlogiſton; and M. *Baumé* proceeding on the ſame theory, thought that in this operation a quantity of nitrous ſulphur was formed, which was inſtantly inflamed. In the year 1780, I read in the Academy a Memoir, in which I have ſhown that nitrate of potaſh is neither combuſtible of itſelf nor yet forms nitrous ſulphur when it detonizes; and that this phenomenon is entirely owing to the ſlower or quicker combuſtion of the combuſtible matter neceſſary to make the ſalt detonize, in conſequence of the diſengagement of the vital air, which eſcapes in great abundance from nitrate of potaſh ſtrongly heated. This theory is completely proved: 1. Becauſe the ſalt never detonizes by itſelf. 2. Becauſe after its detonation by means of an inflammable matter, this matter is found to be entirely burnt up. 3. Becauſe the greater the quantity of the nitrate of potaſh in proportion to that of the combuſtible matter, the more complete is the combuſtion of the latter ſubſtance. 4. Becauſe detonation takes place as well in cloſe veſſels as in the open air, which could not poſſibly happen if the ſalt did not furniſh vital air. This aſſertion receives the fulleſt ſupport from the phenomena attending the proceſs for making the *clyſſus* of nitre; which is merely a detonation of this ſalt with different combuſtible matters in cloſe veſſels. We ſhall mention here only that which is made with charcoal. Two or three large receivers fitted together are applied to a retort of earth or iron, with an orifice in the upper part, which may be cloſed with a cover or ſtopper. This veſſel is heated till its bottom be made red, and then a mixture of nitrate of potaſh with coal is put in by the orifice, which is immediately ſhut. During the detonation, the receivers are filled with vapours, part of which is condenſed into an inſipid liquor, not at all acid, but often alkaline. The reſidue is potaſh ſaturated with carbonic acid: the nitric acid is then totally decompoſed, and a large quantity of gas is produced, which I have collected by fitting to the orifice in the upper part of the receivers, either a bladder or tubes, the extremities of which entered glaſſes full of water. This gas was moſtly carbonic acid mixed with a little inflammable gas and gas azote; the laſt of which is one of the principles of the nitric acid. The inflammable gas is produced in conſequence of the decompoſition of part of the water of nitre by the charcoal.

The reſidue, after the detonation of nitrate of potaſh with charcoal in a crucible, is improperly called *nitre fixed by charcoal:* it is potaſh combined with carbonic acid.

Nitrate of potaſh, when very pure, ſuffers no alteration from the action of the air.

It is eaſily ſoluble; for three or four parts of boiling water diſſolve one of nitre, and boiling water diſſolves a quantity of it equal to twice its own weight. It therefore cryſtalliſes very readily by cooling. On its poſſeſſing theſe two properties is founded the art of extracting nitrate of potaſh from plaſter or rubbiſh containing it. The ſaltpetre-makers put the pounded plaſter or rubbiſh into a veſſel with a hole at the bottom, and cover it with aſhes. Through this matter they pour water; taking care to pour pure water on rubbiſh that has been already waſhed, till it be deprived of all the nitrous matter it contains; and pouring water already impregnated with nitre upon the unwaſhed rubbiſh, in order that it may be completely ſaturated. They next evaporate the lixivium thus formed in copper veſſels. They ſkim off the firſt pellicles, which are only the muriate of ſoda or marine ſalt contained in the rubbiſh. This ſalt they called *grain;* and by their regulations, they are obliged to carry it to the refining houſes. When the water is evaporated to ſuch a degree, that the reſidue when cool muſt become ſolid, they put it into other veſſels in which the nitrate of potaſh is cryſtallized. This ſalt, which is very impure and dirty, is called *nitre of the firſt boiling*. Some chemiſts have been of opinion that the aſhes uſed in making ſaltpetre ſerved only to cleanſe the nitrate of potaſh of certain greaſy impurities; and that opinion appeared to be ſupported by the fact, that theſe matters contain hardly any alkali, and the aſhes of tarmariſk, uſed by the ſalt-petre makers of Languedoc, contain only ſulphate of ſoda. But this ſalt, as well as ſulphate of potaſh, is as uſeful as an alkali for decompoſing the calcareous nitrate, which is found in ſuch abundance in plaſter and rubbiſh, by the way of double elective attraction, as M. Lavoiſier has obſerved with reſpect to the lixiviated aſhes uſed by the ſaltpetre makers of Paris. We ſhall ſay more upon this under the title of *Calcareous Nitrate.*

Nitrate of potaſh of the firſt boiling is always very impure. It contains five other kinds of ſalts beſide pure nitre; namely, muriate of ſoda, nitrate of magneſia, calcareous nitrate, muriate of magneſia, and calcareous muriate; and theſe muſt be ſeparated, if we wiſh to obtain nitrate of potaſh in a ſtate of purity. The mixture is purified of theſe ſalts, by diſſolving it again in the ſmalleſt poſſible quantity of water, and clarifying this boiling liquor by means of bullock's blood, which carries off all impurities by collecting them on the ſurface in the form of a ſcum. This lixivium is then evaporated, and by cooling the reſidue, a nitrate of potaſh is obtained, much purer than the former, which is ſaid to be *nitre of the ſecond boiling.* Still, however, it is vitiated by a certain quantity of muriate of ſoda and mother-water. It is a third time purified by the ſame proceſs, and it then becomes much purer and whiter; and is now *nitre of the third boiling.* As it is made to cryſtalliſe very rapidly, it is obtained in large irregular maſſes; and yet in the middle of the veſſels there is formed a layer of long regular cryſtals, which is called *nitre in ſticks.* Nitre under this laſt form is not uſed in arſenals, being not ſo ſit for making good gun-powder as nitre in large irregular maſſes; becauſe the water which entered into it when it was cryſtallized would retard the combuſtion of the powder.

Chemiſts and apothecaries go on to purify nitre of the third boiling by new ſolutions and cryſtallizations. By this means they are certain of at length obtaining very pure nitrate of potaſh, entirely free of every extraneous mixture, and containing no muriate with either ſoda, lime, or magneſia for its baſe: Though theſe are ſcarce ever entirely taken away where the operation is performed in the great way *.

Nitrate of potaſh appears to be liable to ſome alteration from ſiliceous earth; for by diſtilling it with ſand the acid is ſeparated. This acid comes off colourleſs, but ſome vapours are diffuſed at the time. The reſidue is vitreous in a greater or a leſs degree, according as there was a greater or a leſs quantity of ſand employed, and as the heat was weaker or more intenſe. Sand appears to decompoſe nitrate of potaſh by its tendency to combine with its alkaline baſe: for when nitre is diſtilled,

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* There is no more extraordinary natural or chemical fact than the the production of ſix ſpecies of ſalt, in the rubbiſh of old houſes, each of the alkaline baſes being conſtantly united with a peculiar acid. Potaſh is always united with the nitric acid, and ſoda is always combined with the muriatic. There would ſeem to be ſome particular relations between thoſe different kinds of primary ſalts, in conſequence of which they mutually ſelect each other; for why is there no muriate of potaſh or nitrate of ſoda? The ſame thing might be obſerved of the earthy ſalts: in fact, there is much more muriate of magneſia and calcareous nitrate, than nitrate of magneſia or calcareous muriate: and this ſhows magneſia to have a peculiar affinity with the muriatic, and lime with the nitric acid.—F.

tilled, without any intermediate body being uſed, there is no nitrous acid, but a mixture of vital air with gas azote, obtained. The reaſon of this I take to be, that when nitre of potaſh is diſtilled without an intermedium, the alkali reacts on the acid, and contributes to its decompoſition; whereas, when this ſalt is heated with a mixture of ſand, the ſand, by its tendency to form glaſs by combining with the potaſh, prevents the alkali from reacting on the acid, which therefore eſcapes unaltered. Argillaceous earths likewiſe decompoſe nitre. Coloured clay is generally made uſe of for this purpoſe. The diſtillers of aquafortis in Paris make uſe of an earth of this kind. Into earthen retorts, of a peculiar form, called *cuines*, they put into each two pounds of nitre, of the ſecond boiling, with ſix pounds of coloured clay of Gentilly: the retorts are arranged one beſide another, in long furnaces known by the name of *galleries;* and the neck of each retort enters a bottle of the ſame form, ſerving as a receiver. By this means they obtain at firſt a tranſparent liquor, ſomewhat acid, which they call *phlegm of aquafortis*, and afterwards the acid gradually more and more concentrated. The reſidue is a very hard, red, earthy ſubſtance, which ſerves for making a kind of mortar. But this experiment by no means proves that clay decompoſes nitre of potaſh:—For, 1. The nitre uſed by the diſtillers is very impure, containing a great deal of earthy nitre: 2. The clay which they make uſe of is of a very compound nature, often containing a great quantity of pyrites, the ſulphuric acid of which may poſſibly decompoſe the nitre. In order that this decompoſition may determine the fact in queſtion, it ſhould be made with white clay, or rather with alumine. As this earth has not ſo great a tendency as ſand to unite with the alkali and does not form glaſs by combining with this ſalt, it does not ſeem capable of effecting ſo complete a decompoſition of nitre of potaſh as ſand produces. M. Baumé, however, ſays, that he obtained the acid of nitre of potaſh by the addition of porcelain and clay baked in ſtoneware: but he thinks that the decompoſition of the ſalt was owing to the acid contained in the clays.

Barytes decompoſes nitre of potaſh, and ſeparates the alkali. Bergman, in his table of affinities, places this ſalino-terrene ſubſtance before the alkalis, and immediately after the nitric acid.

Magneſia, lime, and the alkalis, act not upon nitre. But the acids act in a very diſtinct manner on this ſalt, particularly the ſulphuric acid, which has really a greater affinity than the nitric acid with the alkalis. When a quantity of concentrated ſulphuric acid is poured on a quantity of dry nitre of potaſh, a conſiderable effervеſcence is produced, and red vapours are ſeen to ariſe, which are actually nitrous acid. By performing this operation in a receiver with the retort fitted to it, we may collect this acid: it is known by the name of *ſpirit of nitre.* This operation is called in the laboratories, *the diſtillation of the ſpirit of nitre in Glauber's way*; becauſe Glauber was the firſt who gave a plain intelligible deſcription of it. The receiver uſed in this operation muſt be perforated with a ſmall hole, to give vent to the vapours of the nitrous acid. It was remarked, that there was much difficulty in condenſing theſe vapours, and that the proceſs was liable to two accidents. The firſt was, the loſs of no ſmall portion of the ſpirit of nitre which eſcaped through the orifice of the veſſel: the ſecond, the danger to which the operator was expoſed from ſuch extremely acrid and corroſive vapours. This proceſs was therefore very defective. Mr Woulfe, an ingenious Engliſh chemiſt, has found means to obviate theſe inconveniences. Inſtead of uſing a receiver perforated with a little hole, he has adopted one with two necks. Into the extremity of this veſſel, which is fartheſt from the receiver, he puts a tube, one end of which being in an horizontal poſition, makes a right angle with the other, which is vertical and inſerted into a bottle. This bottle has in its ſides two orifices; each of theſe receives a ſyphon which paſſes into another bottle ſtanding beſide the firſt. The two collateral bottles are joined by means of a ſyphon with two others, of which the lateral apertures remain open. The firſt bottle generally remains empty: the collateral bottles contain a quantity of water, in which the lower and longeſt extremity of the tube which communicates between the two, is immerſed: the upper part of the bottles remains empty; and the acid vapour is conducted by the tubes through the bottles. By the uſe of this ingenious apparatus, the artiſt is ſecured from all danger, and nothing is loſt. The nitrous acid in vapour paſſes through the retort into the firſt bottles, and is there condenſed; and what is not condenſed in the firſt paſſes into the ſecond bottles, and there unites with the water. From the lateral apertures of the laſt bottles, there eſcapes a certain quantity of vital air, which may be received into proper glaſſes. This apparatus, as here deſcribed, poſſeſſes one advantage worthy of our notice: When the retort is left to cool at the end of the operation, a vacuum is produced in the veſſels, and the external air preſſing on the water in the outer bottles ſtanding open, forces it through the ſyphons into the inner collateral bottles; and from theſe again it paſſes into the middle bottle ſtanding neareſt to the retort. If the firſt bottle were not empty, or not large enough to contain all the water from the others, the acid liquors would paſs into the receiver: and as the ſtrongeſt nitrous acid is contained in that veſſel, it would be mixed with the liquors from the bottles, and therefore would not poſſeſs the required ſtrength. This circumſtance would be ſtill more inconvenient in other inſtances of diſtillation, of which we are hereafter to ſpeak; becauſe it would not ſimply weaken the ſtrength of the product, but would even alter its purity.

In performing this operation in a laboratory, four pounds of pure nitrate of potaſh, melted into cryſtal-mineral, are put into a tubulated ſtone retort, placed in a reverberating furnace; or tubulated glaſs retorts may be uſed in a ſand-bath. Two pounds and an half of concentrated ſulphuric acid are poured in at once through the aperture, and it is then ſhut. The apparatus above deſcribed, which we ſuppoſe to have been prepared and put together on the preceding evening, is to be inſtantly applied and luted to the retort; it is next to be gradually heated till nothing more comes over. The diſengagement of the gas, and its paſſage into the bottles, ſerve to direct the operator in conducting the proceſs. If the gas appear to be diſengaged with too much rapidity, the heat is then too violent, and muſt be diminiſhed, otherwiſe the whole maſs in the retort will ſwell up and paſs into the receiver: But again, if it paſs too ſlowly, the fire muſt be increaſed to prevent the abſorption of the gas. This apparatus is therefore happily formed to direct the artiſt in the management of his proceſs.

The reſidue, after this decompoſition, is ſulphate of potaſh, formed by the union of the ſulphuric acid with the alkaline baſe of nitre. This reſidue is known in pharmacy under the name of *ſal de duobus*, or *arcanum duplicatum*. It is uſually a white opaque maſs, half vitrified, and filled with cavities produced in it when it was ſwelled by the heat. This ſalt is ſtrongly acid, on account of the quantity of ſulphuric acid made uſe of in producing it; and it is the exceſs of the acid which cauſes the ſalt to melt, as we have ſeen under the hiſtory of ſulphate of potaſh. The nitrous acid obtained by this proceſs is very red and fuming, becauſe the intenſe heat employed in the diſtillation diſengages a portion of vital air. As it is always mixed with a certain quantity of ſulphuric acid, it is to be rectified by a new proceſs of diſtillation on a quantity of nitre equal to one-fourth of its own weight. We muſt likewiſe obſerve, that the nitre made uſe of on this occaſion muſt be very pure, in order to afford nitrous acid in ſuch a ſtate that we may depend upon its effects. That which is obtained from nitre of the ſecond boiling, contains muriatic acid, and acts with the ſolvent power of aqua regia. This acid may be purified of the muriatic acid which it contains by a diſtillation judiciouſly managed; as is ſhown by Meſſrs de Laſſone and Cornette (*Mem. Acad.* 1781, p. 653 to 656).

The concrete boracic acid decompoſes nitre with the help of heat, diſengaging from it the nitric acid in a concentrated ſtate. It appears to effect this decompoſition by means of its fixity; which is the opinion of the academicians of Dijon. Yet it muſt alſo be aſcribed in part to the mutual attraction between the boracic acid and the potaſh baſe of nitre.

Nitre of potaſh is much uſed in the arts. It is the principal ingredient in gun-powder; of which compoſition we ſhall have occaſion to ſpeak under the article of ſulphur. When burnt with various proportions of tartar, it forms the melting matters called *fluxes*, which are uſed in the aſſaying of metals for melting and reducing metallic ſubſtances, &c. &c.

It is often uſed in medicine as a quieting, cooling, refreſhing, diuretic, antiſeptic medicine, &c. It is given in any kind of drink, in doſes of—from ten or twelve grains to half a dram and more. Phyſicians have daily inſtances of its good effects*.

Species

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* Since nitre is a compound of potaſh with azote and oxigene, all matters affording theſe three ſubſtances, will, of courſe contribute to its formation; animal matters, by furniſhing azote; vegetables, as yielding potaſh; the air, as ſupplying oxigene. It effloreſces on the ſurface of uncultivated grounds. It is formed on the paſture grounds of cattle. It is diſperſed even in the duſt of the roads of Spain. Cheſnuts ſupply a material for its formation. M. Virengue has found, that it is produced in all extracts capable of fermentation, The diſtillation of nitrate of potaſh, affords 12000 cubic inches of oxigene, for each lib. of the ſalt: 7 parts of water, diſſolve 1 part of nitre at 60° Fahrenheit: and boiling water diſſolves a quantity equal to itſelf in weight. 100 grains of the cryſtals of nitre contain 30 acid, 63 alkali, and 7 water.—H.

Species IV. *Nitrate of Soda.*

Nitrate of ſoda, which has been called *cubic, quadrangular,* and *rhomboidal nitre,* is a perfect neutral ſalt, reſulting from a ſaturated combination of the nitric acid with ſoda.

This ſalt generally appears in pretty large and very regular rhomboidal cryſtals. The name of *rhomboidal nitre* deſcribes it better than that of *cubic nitre.*

Its taſte is freſh, and rather more bitter than that of nitre of potaſh.

Fire decompoſes this as well as the preceding ſalt; but it decrepitates, and does not melt ſo eaſily as the other. It affords a mixture of vital air with gas azote, with an alkaline reſidue like nitre of potaſh.

It is rather more ſubject than nitre of potaſh to alteration from the air, and attracts moiſture, though not with much force.

It diſſolves in cold water even more readily than the former ſalt; for two parts of water, at the ordinary temperature of 60°, are ſufficient to diſſolve one part of nitrate of ſoda. Boiling water ſcarce diſſolves it in a greater proportion: and therefore, when we wiſh to obtain it in regular cryſtals, the ſolution muſt be ſlowly evaporated. If a tolerably clear lixivium of this ſalt be ſet aſide in a dry place,—at the end of ſome months it is found to contain rhomboidal cryſtals, ſix or eight lines, and ſometimes near an inch long. This is uſually the happieſt proceſs for cryſtalliſing ſalts that are as ſoluble in cold as in warm waters.

Nitre of ſoda detonizes on burning coals, and inflames any combuſtible body heated along with it,—rather more ſlowly than nitre of potaſh.

Siliceous earth diſengages the nitric acid, and unites with its baſe to form glaſs. Clay alſo ſeparates the acid, giving as a reſidue a kind of frit, which becomes porous and opaque after being expoſed to a ſtrong heat.

Barytes decompoſes it, and leaves the ſoda pure. Magneſia and lime produce no ſenſible alteration upon it.

Potaſh having more affinity than the baſe of this ſalt with the nitric acid, attracts it to itſelf, and forms with it nitre of potaſh. We obtain conviction of the truth of this fact by a very ſimple experiment. If a boiling ſaturated ſolution of nitre of ſoda be divided into two portions, and into one of theſe there be thrown a quantity of cauſtic potaſh, the portion which received this addition will depoſite, when it cools, priſmatic cryſtals of nitre of potaſh; while the other into which there was no potaſh put, will exhibit no cryſtals at all, becauſe nitre of ſoda cryſtalliſes only by a very ſlow evaporation.

If concentrated ſulphuric acid be poured upon nitrate of ſoda, it will diſengage the nitrous acid with effervеſcence. Nitric acid is obtained by a diſtillation of this mixture, as well as from nitre of potaſh. The other mineral acids act no more on this ſalt than on the foregoing.

The neutral ſalts which has been already examined, ſulphate of potaſh and ſoda, and nitrate of potaſh, produce no alteration on nitrate of ſoda. When theſe ſalts are all diſſolved in the ſame water, they cryſtallize ſeparately, each in its ordinary way: Nitrate of potaſh and ſulphate of ſoda, by cooling; ſulphate of potaſh and nitre of ſoda, by evaporation. From all theſe properties it appears, that nitrate of ſoda differs from nitrate of potaſh only in its form, its taſte, its ſlight tendency to deliquiate, its being of eaſier ſolution, its cryſtalliſing by evaporation, and chiefly by its ſuſceptibility of decompoſition by potaſh.

Nitrate of ſoda has not been yet found in nature. It is always a product of art, and is formed in the five following ways: 1. By the direct combination of the nitric acid with ſoda. 2. By decompoſing with this alkali, earthy nitrates, ammoniacal nitrate, and metallic nitrates. 3. By decompoſing muriate of ſoda with the nitric acid for an intermedium. 4. By decompoſing ſulphate of ſoda by the fuming ſpirit of nitre. 5. By decompoſing ſuch nitrous ſolutions of metals as are ſuſceptible of it, with muriate of ſoda: In this inſtance, in proportion as the muriatic acid combines with the metal, ſeparating from it the nitric acid, the ſeparated acid combines with the ſoda, which has alſo deſerted the acid with which it was before united. All theſe decompoſitions will be particularly deſcribed in the reſpective hiſtories of the ſalts which are liable to them.

Nitrate of ſoda might be employed for the ſame purpoſes as nitrate of potaſh. But as it does not produce all the effects of that ſalt, doubtleſs on account of its having a greater affinity with water, it is not made uſe of in the arts. Beſides, as it is not found in nature, but is merely a product of art, no attempt has been made to apply it to any particular uſe. A ſufficient number of experiments has not yet been made on this ſalt to make us acquainted with all its properties*.

Species V. *Muriate of Potaſh.*

Muriate of potaſh, which was formerly called *febrifuge ſalt of Sylvius*, is a ſaturated combination of the muriatic acid with potaſh. It has been improperly named *regenerated marine ſalt;* for the nature of its baſe renders it different from that ſalt. Its cryſtals are cubic, but always of a confuſed appearance, and rather an irregular form. Its taſte is ſaline, pungent, bitter, and diſagreeable. When expoſed to fire, it decrepitates; that is to ſay, its cryſtals break into ſmall pieces; which is occaſioned by the ſudden rarefaction of the water which enters into their compoſition. If ſuffered to remain in the fire after decrepitation, it melts and is volatiliſed, but not decompoſed. It may be uſed as a flux for earths and metallic ſubſtances. Its chief uſe in ſuch caſes is to cover the matters to be melted, and by this means fix the action of other fluxes employed, hindering them from becoming volatile, and preventing ſuch alterations as might be occaſioned by the acceſs of air.

Muriate of potaſh is ſubject to little alteration from the air, as it ſcarce attracts moiſture.

About three parts of cold water are neceſſary to maintain in ſolution one of this ſalt; nor has hot water any greater power of diſſolving it. For this reaſon a ſlow evaporation is uſed, to give it in cryſtals. It is

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* 100 grains nitrate of ſoda, contain 28.80 acid, 50.09 alkali, 21.11 water.—H.

one of thoſe ſalts which it is very difficult to obtain in regular cryſtals of a certain ſize.

Clay ſeems to decompoſe it in part: for muriatic acid may be obtained by diſtilling this ſalt with the clays in the neighbourhood of Paris. That operation indeed affords but a ſmall quantity of the acid, and its reſult is very different from that which nitrate of potaſh affords. Sand is alſo known to act in the ſame manner as clay on muriate of potaſh.

Barytes, according to Bergman, ſeizes the acid, leaving the potaſh in a ſeparate ſtate. Magneſia and lime produce no alteration on this ſalt.

The ſulphuric and the nitric acids diſengage the muriatic with efferveſcence *. This phenomenon is the more ſtriking, if the potaſh be dry. Muriate of potaſh, after decrepitating, and loſing the water of its cryſtals, gives a very conſiderable efferveſcence with the concentrated ſulphuric acid, and the mixture becomes very warm. Where theſe decompoſitions are performed in retorts, muriatic acid paſſes into the receiver,

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* We have already obſerved, when ſpeaking of the decompoſition of nitre of potaſh by the concentrated ſulphuric acid, that the nitrous acid is then diſengaged with a lively efferveſcence. We find the muriatic acid exhibiting the ſame phenomenon; in a much more eminent degree indeed, becauſe this acid has a very ſtrong tendency to aſſume the gaſeous ſtate. This is the general cauſe of all efferveſcences, the nature and diſtinctions of which have, till of late, been but very imperfectly known. It was formerly thought that they were owing to the diſengagement of air: we now know them to be produced, not by air, but by all bodies which have any tendency to the ſtate of aëriform aggregation; and thus we have ſhown, that the ebullition of water may be conſidered as a ſort of efferveſcence. As this truth needs to be frequently repeated, in order that it may become generally known, we ſhall take occaſion to recur to it ſeveral times when treating of the different neutral ſalts which admit of decompoſition by acids.—F.

ceiver, and the reſidue in the retort is found to be ſulphate of potaſh,—if the ſulphuric acid was employed to effect the decompoſition; but if the nitric acid was uſed, aqua regia is obtained in the receiver, and the reſidue is nitre of potaſh. The boracic acid likewiſe decompoſes muriate of potaſh by diſtillation, diſengaging the muriatic acid. As all of theſe operations are done with muriate of ſoda or marine ſalt, we ſhall give a more particular account of them under that article. Neither the fluoric nor the carbonic acid acts in any way on muriated potaſh.

Neither ſulphate nor nitrate of potaſh or ſoda acts upon this ſalt. When all are diſſolved in the ſame water, each of them is cryſtalliſed ſeparately and in its own way.

Muriate of potaſh is frequently met with in nature; but never much of it together. It is found in ſea water, and in the water of ſalt ſprings; ſometimes, though not often indeed, it is met with in the ſame places where nitre of potaſh is found; it is alſo found in aſhes of vegetables, and in ſome animal humours. Art produces it, 1. By a direct combination of the muriatic acid with potaſh; 2. By decompoſing earthy, ammoniacal, or metallic muriates by the ſame alkali; 3. By decompoſing ſulphate or nitrate of potaſh, by means of the muriatic acid, as M. Cornette has ſhown.

This neutral ſalt was formerly adminiſtered as an excellent febrifuge. But it poſſeſſes not this property otherwiſe than in common with all bitter ſalts. Sulphate of potaſh or ſoda is now preferred to it.

Muriate of potaſh is applied to no uſe in the arts.

Its diſagreeable taſte hinders it from being uſed, like muriate of ſoda, for ſeaſoning. But it has all the chemical properties of that ſalt; and the only difference between them is, that muriate of potaſh has a bitter taſte, is more difficult of ſolution, is unalterable by the air, and is irregularly cryſtalliſed. We ſhall therefore inſiſt no more upon its hiſtory *.

Species VI. *Muriate of Soda.*

Muriate of ſoda, better known under the name of *culinary* or *common ſalt*, is a perfect neutral ſalt, formed by a ſaturated combination of the muriatic acid with ſoda. The reader will perceive that the nomenclature which we have hitherto uſed, renders a definition of the nature of theſe neutral ſalts almoſt unneceſſary; as the name of each is expreſſive of its nature.

This ſalt abounds in nature more than any other ſpecies. It is found in vaſt maſſes in the interior parts of the earth, in Spain, Calabria, Hungary, and Muſcovy, but more eſpecially at Wieliczka in Poland, near the Crapack mountains †. In the laſt of theſe places the mines are of vaſt extent, and the muriate of ſoda is found in prodigious maſſes. This ſalt, as it exiſts in the earth, is generally irregular, and ſeldom cryſtalliſed; it is uſually more or leſs white, but ſometimes coloured: in this ſtate it is called *ſal-gem*, having often the tranſparency of the cryſtals known under that name. The waters of the ſea, as well as of ſome lakes and rivers, contain this ſalt. From theſe waters it is obtained by four general proceſſes.

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* 100 grains of muriate of potaſh, contain 29,68 acid, 63,47 alkali, and 6,85 water.—H.

† It is found alſo in *Switzerland* and *Tyrol*, and at Northwich in Cheſhire in England: and it has been inferred from the exiſtence of the ſalt ſprings in *Lorraine* and *Franche-Comté*; that there are ſalt mines in the bowels of the earth, in theſe diſtricts of the French territory.—Strata of foſſil ſalt probably owe their origin to the natural deſiccation of lakes of ſalt water, or from the precipitation of the ſalt, by a natural proceſs in ſuch lakes. For a good account of the manner of working ſalt mines, See *Memoire ſur le Sel Marin, par M. Haſſenfratz*; *Annales de Chimie*, tom. XI. p. 65.—H.

The firſt is ſpontaneous evaporation by the heat of the ſun. This method is uſed in our ſouthern provinces, in Languedoc, at Peyrac, Pecais, &c. Trenches are cut on the ſea ſhore, and very compactly lined with clay: within theſe trenches little walls are built, dividing them into certain compartments, yet leaving a general communication. When the tide flows, the trenches are filled with water, which is retained in them by the walls forming a kind of ſluice-gates. Care is taken that the layer of water retained be thin enough to be readily evaporated by the rays of the ſun. As ſoon as a ſaline pellicle is formed, it is broken, and the fragments fall to the bottom; and the ſame proceſs is repeated till the water be entirely evaporated. The ſalt is then gathered with rakes, and laid in heaps to dry. This ſalt contains a mixture of all the other ſalts that exiſt in a ſtate of ſolution in ſea-water, ſuch as ſulphate of ſoda and magneſia, muriate of magneſia and lime: it is alſo contaminated with a portion of clay from the bottom of the trench: and, laſtly, ſmall globules of iron and mercury are found in it. The exiſtence of the latter in it may be eaſily ſhown by leaving a ſmall piece of gold among the ſalt for ſome time: it becomes evidently whiter. This ſalt being very impure, is known under the name of *ſel de gabelle.*

In the northern provinces of France, in Normandy and Brittany, this ſalt is prepared by an artificial evaporation by fire. In Avranches they take the quickſands among which the ſea water has depoſited ſaline cryſtals, and waſh them in the ſmalleſt quantity poſſible of ſea water, in order that no more may be uſed than what is neceſſary to diſſolve the ſalt: This ſalt water is then put into lead veſſels, and evaporated to dryneſs. This ſalt is very white, and purer than that prepared by evaporation in trenches. Guettard has given a careful deſcription of the whole proceſs in the Memoirs of the Academy for the year 1758.

In Lorraine and Franche-Comté there are many ſalt ſprings. The quantities of muriate of ſoda which thoſe ſprings contain in proportion to the quantity of water are various. At Montmorot, in the laſt of theſe provinces, both ſpontaneous evaporation and evaporation by fire are uſed in the preparation of this ſalt. For that purpoſe, the well-water is conveyed by pumps into a large reſervoir placed at the top of a ſhed of a peculiar conſtruction. Under this ſhed are ſuſpended boards covered with little faggots of thorns. The water falling upon theſe faggots through ſmall cocks, is divided into very minute drops: and as it thus expoſes a great deal of ſurface to the air circulating rapidly under the ſhed, nearly two-thirds of it is evaporated. What is depoſited on the faggots is ſulphate of lime or ſelenite. And when the liquor, upon trial with an inſtrument for the purpoſe, is found to be charged with ſalt to a certain degree, it is conveyed into large iron boilers ſupported by bars of the ſame metal, which croſs the bottoms of the veſſels, and reſt on pieces of wood placed on each ſide. Theſe boilers which are called *ſtoves*, are very large and ſhallow, and hold an hundred hogſheads * of the ſalt water. They are then urged with a ſtrong fire. When the water boils up in large bubbles, it is at firſt muddy, and ſoon depoſites an ochreous earth on its ſurface in the form of a ſcum. A ſalt, which is ſcarcely ſoluble, and is called by the workmen *ſchlot*, is next ſeparated: This ſalt is nothing but ſulphate of lime mixed with a little muriate of ſoda, ſulphate of ſoda, and earthy muriates. It is conveyed by the circulation of the boiling liquor into little troughs placed round the ſides of the boilers for the purpoſe. Theſe troughs are taken out, and cleared from time to time, till a great quantity of ſmall cubical cryſtals called by the workmen *pieds de mouches*, are obſerved floating on the ſurface of the liquor. They are then taken away for the laſt time. The fire is diminiſhed, and the muriate of ſoda is taken off with ladles as faſt as it is cryſtallized. The evaporation is thus continued as long as the water continues to afford cryſtals. The ſalt thus obtained is in larger or ſmaller cryſtals, according to the ſlowneſs or rapidity of the evaporation. The water which remains when cryſtals are no longer obtained, is called *mother water*, and contains earthy muriates †.

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* *Muids*, containing each 380 French pints.

† There is a neutral ſalt prepared at Montmorot, known under the name of *Epſom ſalt of Lorraine*; but it is only ſulphate of ſoda, or Glauber ſalt, the cryſtallization of which has been diſturbed. It is

Wallerius gives an account of a fourth proceſs for obtaining ſalt from ſea water, which is practiſed in the north. The water is confined in trenches on the ſhore; as it forms but a ſmall ſtratum, the cold ſoon penetrates through and freezes it. But as that portion neceſſary for the ſolution of the ſalt contained in the whole quantity of water cannot be converted into ice, what remains fluid contains all the ſalt, and is ſo concentrated that the moſt moderate heat cauſes it to afford muriate of ſoda in cryſtals: it is then conveyed into leaden boilers, and evaporated by fire.

The cryſtals of muriate of ſoda are very regular cubes of a larger or ſmaller ſize, in proportion as the evaporation has been ſlower or more rapid. They ſtick together in cluſters, forming a kind of ladders, or rather hoppers. Rouelle the elder obſerved this phenomenon, and has given an accurate deſcription of it in his Memoirs on Cryſtallization. Bergman has given a very ingenious explanation of this fact.

Every body knows the taſte of this ſalt, which is not diſagreeable.

When expoſed to a briſk heat it burſts and flies into pieces. This phenomenon is called *decrepitation*. It is owing, as we have already obſerved when ſpeaking of ſulphate and muriate of potaſh, to the ſudden rarefaction of the water on which the cryſtallization depends. When all the water is thus evaporated, the decrepitation ceaſes, and the ſalt appears in a powder. If

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diſtinguiſhed from genuine ſulphate of magneſia and Epſom ſalt, ſuch as comes from England, by its efflореſcing in the air, while the latter deliquiates.—F.

If we continue to urge it with a ſtrong heat, it melts after becoming red-hot. If poured in this ſtate on the plane ſurface of a piece of marble, it congeals into a kind of cryſtal mineral; but it has not ſuffered the leaſt alteration, for it may be reſtored to its original form by ſolution in water. Fire therefore does not decompoſe it: if maintained for ſome time in fuſion, it is at length volatilized, but ſtill without alteration. The moſt intenſe heat is requiſite to bring it into this laſt ſtate.

Muriate of ſoda when pure ſuffers no ſenſible alteration from air; it rather becomes dry than acquires moiſture. It never indeed attracts moiſture but when it contains a mixture of muriates with earthy baſes, ſuch as in *ſel de gabelle.*

It diſſolves very readily in water: three parts of the fluid are ſufficient to maintain one of this ſalt in ſolution. Three ounces and an half of water will entirely diſſolve an ounce of the ſalt. Boiling water does not diſſolve it in a greater proportion than cold water; only the ſolution is rather ſooner effected with the help of heat. A very ſlow evaporation is requiſite to give this ſalt in cryſtals. The cryſtallization begins with the formation of a number of ſmall points on the ſurface of the liquor, which are gradually united in a pellicle, more or leſs thick; inſtead of being cubic, the cryſtals are ſometimes ſquare hollow pyramids, reſembling hoppers. Rouelle the elder, who paid the greateſt attention to all the phenomena of this cryſtallization, obſerved the hoppers to be formed in the following manner. When a cube is formed, the little ſolid ſinks a ſhort way beneath the ſurface of the water; a ſecond is ſoon formed, and connected with the firſt on one of its ſides; and the ſame phenomenon takes place on the three other ſides of the cube. This aggregation of cubic cryſtals naturally produces narrow inverted pyramids. When theſe are large they ſink to the bottom. If the ſalt diſſolved was very pure, what remains of the water after it has been evaporated till it would afford no more cryſtals, is entirely without any ſaline matter. The water of the ſea and of ſalt ſprings always contains ſalts with an earthy baſe. The earth may be precipitated by ſoda, as we ſhall have occaſion to mention when ſpeaking of earthy neutral ſalts. Such is the method uſed for obtaining muriate of ſoda in a ſtate of great purity.

Muriate of ſoda appears to contribute to the fuſion of glaſs. It conſtantly occupies the upper part of the pots in which this matter is melted, and conſtitutes the greateſt part of glaſs-gall.

It is uſed for vitrifying the exterior ſurface of certain pottery wares, and for giving them a kind of cover, by melting down part of their ſubſtance with the force of heat communicated through the ſalt. This is eaſily effected by throwing a certain quantity of muriate of ſoda into the furnace. It is volatilized, and by this means ſpread over the ſurface of the earthen ware, which, by its intenſe heat, it cauſes in part to melt. This is the Engliſh way of glazing.

Siliceous earth does not alter this ſalt, though it appears to promote its fuſion.

Pure clay acts with much leſs force on muriate of ſoda than on nitres. When diſtilled with this ſalt, it affords but a very ſmall quantity of a weak phlegmatic acid. Diſtillers of aquafortis, it is true, obtain in this manner the muriatic acid called *ſpirit of ſalt:* but they make uſe of *ſel de gabelle* for the purpoſe; and it contains various muriates with an earthy baſe; beſides, the clay which they uſe is very impure, and of a deep colour.

According to Bergman's experiments, barytes decompoſes muriate of ſoda, as well as the other alkaline ſalts; neither lime nor magneſia produces any alteration on muriate of ſoda. Perhaps theſe two ſalino-terrene ſubſtances, in combination with the carbonic acid, might ſeparate the component principles of muriate of ſoda by a double elective attraction.

Cauſtic potaſh decompoſes muriate of ſoda, having a greater affinity than ſoda with its acid. A ſolution of muriate of ſoda mixed with potaſh, gives by evaporation muriate of potaſh, and the mother water contains pure inſulated ſoda.

Acids act in a very diſtinct manner on muriate of ſoda. When concentrated ſulphuric acid is pour-ed on this ſalt, it cauſes a very conſiderable motion and a very lively heat. A violent efferveſcence is obſerved on the occaſion *, which ariſes from the diſengagement of the muriatic acid under the form of gas. This aëriform acid may be diſtinguiſhed after it has eſcaped into the atmoſphere, as it forms a white vapour with the water in the air, and has, when the vapour is very much diluted, a pungent ſmell not unlike that of ſaffron. A conſiderable quantity of muriatic acid gas may be obtained by performing the operation with a pneumato-chemical machine provided with mercury. Glauber was the firſt who obſerved that the acid of marine ſalt might be obtained by decompoſing the ſalt with ſulphuric acid, and deſcribed the proceſs for obtaining it; on which account this has received the name of *Glauber's ſpirit of ſalt.* It was in examining the reſidue of this operation that he diſcovered his admirable ſalt to which we now give the name of *ſulphate of ſoda.*

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* Efferveſcence is as obſervable in this operation as in the union of the ſame acid with lime and alkalis ſaturated with carbonic acid. It takes place, therefore, whenever any body ſeparated from a ſtate of combination is volatilized under a gaſeous form: and it may be produced by the carbonic, the muriatic, the nitric, the ſulphureous, and the fluoric acids, &c." It muſt not be aſcribed to the diſengagement of air.—F.

Almoſt all writers on the ſubject, direct the diſtillation of this ſalt to obtain the muriatic acid, to be performed by putting a quantity of it into a tubulated ſtone-retort, and pouring in at the orifice half its weight of concentrated ſulphuric acid: A conſiderable quantity of acid vapour is immediately diſengaged, which paſſes by the extremity of the retort into two balloons prepared to receive it: One of theſe veſſels has a little hole to let the vapours eſcape, ſo that they may not burſt the veſſels. In this operation, as well as in the diſtillation of the nitrous acid, a conſiderable quantity of the pureſt muriatic acid is loſt,—eſcaping in a gaſeous form through the hole of the balloon; and the vapours of this acid being ſo very corroſive, are exceedingly troubleſome to the operator. To obviate in part this inconvenience, M. Baumé puts a quantity of water into the retort; and the water being volatilized in the balloon, abſorbs part of the muriatic acid gas: But as the water is much leſs volatile than the acid, there is ſtill a conſiderable quantity of the acid loſt. Mr Woulfe has found means to obviate all theſe inconveniences, and to procure the muriatic acid in the ſtrongeſt and moſt concentrated ſtate of which it is capable, by an expedient directly contrary to M. Baumé's. Inſtead of volatilizing the water, to make it abſorb the vapours of the muriatic acid, he cauſes the gas to paſs through that liquid by the apparatus which we deſcribed under the article of nitre.

For every two pounds of muriate of ſoda and one of the concentrated ſulphuric acid that are mixed in the retort, eight ounces of diſtilled water are put into the collateral bottles. The muriatic acid gas is conducted through the tubes into the water in the bottles, and there diſſolved. The water, as it combines with the gas, is heated almoſt to ebullition, and abſorbs a quantity equal to itſelf in weight. When fully ſaturated, it ceaſes to abſorb the gas and becomes cold; but the gas paſſing into the ſecond collateral bottles, is again immerſed in the water which they contain, and heats and ſaturates it.

This very ingenious proceſs being perfectly conſiſtent with the known properties of the muriatic acid gas, poſſeſſes a number of advantages. 1. It ſecures the operator from the inconveniences to which he is expoſed when the acid is diffuſed through the open air. 2. It prevents the very conſiderable loſs of the acid, which was unavoidable in M. Baumé's proceſs. 3. It gives the muriatic acid in a ſtronger, more concentrated, and more fuming ſtate than we could poſſibly have it otherwiſe. 4. The acid obtained this way is extremely pure, being entirely formed of gas that has been diſſolved in water. It is on this account extremely white; whereas that which was formerly obtained in the laboratory was always of a citron colour; a circumſtance which even led chemiſts into a miſtake, for they conſidered this colour as a characteriſtic property of the acid. That portion of the liquid acid which is in this proceſs condenſed in the receiver is yellow, and contaminated with extraneous matters conveyed into it by the water of the mixture, as happened to the whole of what was obtained in the old way. 5. The new method directs the operator what ſtrength of fire to uſe, and how to conduct his operation by the ſlower or quicker paſſage of the gaſeous muriatic acid through the water in the bottles. 6. Laſtly, what is of more importance than any of its other advantages, it enables us to determine the preciſe quantity of acid contained in any neutral ſalt, as not a particle of the acid ſeparated is loſt.

The nitric acid likewiſe decompoſes muriate of ſoda; but, being volatile, it aſcends and unites with the acid of this ſalt. From this union reſults the mixed acid known by the name *nitro-muriatic acid*, or *aqua regia*.

Baron has diſcovered that the boracic acid, with the help of heat, diſengages the acid from muriate of ſoda. The reſidue, after this diſtillation, is genuine borax of ſoda in a very pure ſtate.

Neither the carbonic nor the fluoric acid acts in any diſtinct manner on muriate of ſoda.

None of the neutral ſalts hitherto deſcribed by us acts upon this ſalt. When ſulphate and nitrate of potaſh and ſoda and muriate of potaſh are diſſolved in the ſame water with muriate of ſoda, each of theſe ſalts cryſtalliſes by itſelf, and in its own way. Muriate of ſoda is among the firſt which are ſeparated in the progreſs of the e poration, and it mixes with a little of the ſulphate and muriate of potaſh; but the ſulphate of ſoda and nitrate of potaſh remain longer in ſolution, and are cryſtalliſed by the cooling of the liquid. On this account, in Lorraine, the mother-water, from which marine ſalt has been obtained, is put into veſſels, and ſtirred while it cools, with ſtaves for the purpoſe; which cauſes the ſulphate of ſoda to cryſtalliſe in a confuſed manner, in ſmall needles, reſembling thoſe of genuine Epſom ſalt, or ſulphate of magneſia.

The uſes of muriate of ſoda are extremely various: It is employed, 1. For glazing ſome kinds of earthen ware by occaſioning a ſlight fuſion of their exterior ſurfaces. 2. By glaſs-makers, for whitening and purifying glaſs. 3. In aſſaying metallic ores, as a flux to the matters of which the ſcoriæ are formed, to facilitate the precipitation of the metals, and to defend them from the contact of the atmoſphere; ſo that they may ſuffer no change from the air.

At preſent we find it neceſſary to apply it to a purpoſe of ſtill more importance than any or theſe,—for the extraction of ſoda, which is becoming every day more ſcarce, and is of eſſential uſe in many of the arts. Several people in England poſſeſs the ſecret of obtaining ſoda from marine ſalt in the great way *, and practiſe it in conſiderable extent.

Some chemiſts have thought litharge capable of decompoſing muriate of ſoda by ſimple maceration and cold. It would appear that, in conſequence of its containing

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* We underſtand that the extraction of ſoda from marine ſalt is not practiſed in England to ſuch extent as M. Fourcroy ſeems to think.—H.

taining carbonic acid capable of attracting ſoda, and forming with the muriatic acid an inſoluble ſalt, eaſily ſeparable from the alkaline lixivium, it muſt act by a double elective attraction; but the experiments which I have made on this point, convince me that the proceſs is inadequate to the purpoſe. Scheele obſerved, that iron immerſed in a ſolution of muriate of ſoda is coated with ſoda ſaturated with carbonic acid. He treated ſulphate and nitrate of ſoda in the ſame manner, with the ſame ſucceſs. He diſcovered, that quicklime mixed with muriate of ſoda, if the mixture were depoſited in a damp cellar, afforded an efflorefcence of ſoda and calcareous muriate. This fact was firſt communicated to the public by Cohauſen in the year 1717. M. de Morveau has proved, that theſe decompoſitions are effected by means of the carbonic acid; for if a ſolution of ſulphate and muriate of potaſh be poured upon lime-water precipitated by the carbonic acid, it becomes clear and tranſparent; but when water containing carbonic acid, is poured on a ſolution of thoſe ſalts mixed with lime-water, no precipitation takes place. Theſe facts are ſo many *data*, on which we muſt proceed in attempts to obtain ſoda from marine ſalt, and to form extenſive eſtabliſhments for the purpoſe.

Muriate of ſoda is uſed as ſeaſoning to the articles of our food, and corrects their inſipidity. It likewiſe facilitates digeſtion, by beginning the putrid alteration of the ſubſtances we uſe for aliment. Though it be fully proved by the experiments of Pringle, Macbride, &c. that when mixed in a pretty large proportion with animal ſubſtances, it retards putrefaction, and is powerfully

fully antiſeptic, like moſt other ſaline matters; yet it acts in a very different manner when mixed with the ſame ſubſtances, in a very ſmall proportion, cauſing them to paſs more readily into a ſtate of putrefaction. This is proved by the experiments of the author of the Eſſays on the Hiſtory of Putrefaction, and by M. Gardanne's experiments.

The ſalt is not leſs uſeful in medicine. In apoplectic and paralytic caſes, &c. it is put into the mouth, and uſed externally in baths, as an excellent ſtimulant. In moſt caſes it is a powerful diſcuſſive. It is ſtrongly recommended by Ruſſel (*de Tabe Glandulari*) for lymphatic tumours, occaſioned by a ſcorbutic habit. I have myſelf preſcribed it ſucceſsfully for ſeveral diſeaſes of that kind. It is purgative when adminiſtered in doſes of ſeveral drams. As the moſt impure ſalt is commonly uſed on all theſe occaſions, its effects are in part to be aſcribed to the calcareous and magneſian muriates which it contains *.

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* The water of the Baltic ſea is ſaid to contain $\frac{1}{64}$ of its weight of ſalt; the water of the ſea between France and England contains $\frac{1}{32}$ of its weight of ſalt. On the coaſts of Spain, the water of the ſea has $\frac{1}{16}$ of ſalt. Between the tropics, the ſea-water is ſaid to have from $\frac{1}{8}$ to $\frac{1}{11}$ of ſalt. The *Jeltonic* ſalt water lake, in the Ruſſian dominions, was once almoſt ſolid with ſalt, ſo that heavy waggons were driven upon it as upon ſtrong ice. But, in the year 1757, the proportion of the water began to increaſe. And it has ſince increaſed ſo much, as to form now within the baſon, only a lake ſtrongly impregnated with ſalt.—H.

Species VII. *Borax of Soda, or Super-ſaturated Borate of Soda* *

Borax of ſoda, or common borax, is a neutral ſalt, formed by the combination of the boracic acid with ſoda. We get this ſalt from the Eaſt Indies; but its hiſtory is very little known. We know not certainly whether it be a product of nature or of art †. If the diſcovery of the boracic acid exiſting in a ſtate of ſolution in the waters of ſeveral lakes in Tuſcany, a fact which we mentioned in the hiſtory of that acid, give us reaſon to think borax a product of nature, a variety of facts which we ſhall hereafter mention, concur to ſhow that this ſalt may be alſo formed by certain artificial proceſſes, as well as nitre.

Borax of ſoda appears in commerce in three different ſtates. In the firſt, it is crude borax, *tinckal* or *chryſocolle* This we get from Perſia; it is in greeniſh maſſes which feel greaſy, or in opaque cryſtals, coloured like green leeks, which are priſmatic figures of ſix faces, terminating in irregular pyramids. There are even two kinds of theſe greeniſh cryſtals, differing from each other in ſize. This ſalt is very impure, a great many extraneous ſubſtances being intermixed in it.

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* Hitherto we have begun with examining the neutral ſalts formed by the union of the acids with potaſh. But, in ſpeaking of thoſe into which the boracic acid enters, we are obliged to begin with that which has ſoda for its baſe, for it is the only one with which we are well acquainted.—F.

† Kirwan, in his mineralogy, page 206. informs us, that it is dug out of the earth in the kingdom of Thibet, in a cryſtalline form. In the Philoſophical Tranſactions for the year 1787, we are informed by a letter from Mr Blane, dated at Lucknow, that the borax of Thibet is formed in a certain valley in that country, by the co-operation of ſnow and the waters of a lake in the middle of the valley, with a ſaline matter which abounds over the valley.—H.

The ſecond ſpecies is known by the name of *China borax.* It is rather more pure than the former: it appears in the form of ſmall plates, or in maſſes irregularly cryſtalliſed, and of a dirty white colour: it diſplays the beginnings as it were of priſms and pyramids confounded together without any ſymmetrical arrangement. The ſurfaces of theſe cryſtals are covered over with a white duſt, which is thought to be of an argillaceous nature.

The third ſpecies is Dutch or refined borax. It appears in fragments of cryſtals, tranſparent and tolerably pure: pyramids with a number of faces are obſerved in it; but their cryſtalliſation appears to have been interrupted. This form affords a certain indication of the manner in which the Dutch purify this ſalt; it is by ſolution and cryſtalliſation.

Laſtly, It is prepared at Paris by Meſſrs Leſguillers, druggiſts in Lombard-Street: and their purified borax is no way inferior, perhaps even ſuperior, in purity to the Dutch borax.

Beſide theſe four kinds of borax, M. la Pierre apothecary in Paris has imagined it to be formed in a mixture of ſoap-ſuds with dirty kitchen-water, which a certain individual preſerves in a ſmall trench, obtaining from it at the end of a certain time genuine borax in beautiful cryſtals. But this fact, though firſt communicated to the public ten years ſince, has not received confirmation *.

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* Ten years, at the date of the publication of the 3d edition of this work.—H.

We are ſtill ignorant therefore in what manner borax is formed; only it appears to be produced in ſtagnant waters containing fat matters. Some authors aſſure us, that it is artificially compoſed in China, by mixing in a trench, greaſe, clay, and dung, in alternate layers, watering this collection of matters at proper times, and leaving it untouched for ſeveral years. At the end of this time, by forming thoſe matters into a lixivium, and evaporating the lixivium, crude borax is obtained. Others would perſuade us, that it is got out of water filtered through copper ore. M. Baumé poſitively aſſerts that the former of theſe proceſſes ſucceeded very well with him. *Chem. Eper. Tom. II. page* 132.

Purified borax appears under the form of ſix-ſided priſms, two of the ſides larger than the reſt, with trihædral pyramids. It diſplays many varieties in its cryſtalliſation. Its taſte is ſtiptic and urinous. It communicates a green colour to ſyrup of violets, on account of its containing an extraordinary proportion of ſoda. We leave it in poſſeſſion of the name of borax, in order to diſtinguiſh it from genuine *borate of ſoda,* which is ſaturated with the boracic acid: we likewiſe call it *borax ſuper-ſaturated with ſoda,* to indicate the nature of the combination.

When expoſed to the action of fire, the water of its cryſtalliſation cauſes it to melt with great rapidity; it gradually loſes that water, and ſwells to a conſiderable bulk. It is then in the form of a light, porous, and very friable maſs, known by the name of *calcined borax.* The cauſe why borax of ſoda increaſes in bulk, and aſſumes a lamellated porous form, on being calcined,

cined, is, that the water which is diſengaged into a vaporous ſtate, raiſes to the ſurface a portion of the ſaline ſubſtance half dried, and in light thin pellicles; and the bubbles in which it riſes, making their way out at the ſurface, the pellicles become entirely dry, and are arranged one above another with interſtices between them. Calcination produces no alteration on borax of ſoda, as to its component parts: it loſes, in undergoing this proceſs, nothing but the water which mixed with it in cryſtalliſation, nearly in the proportion of ſix ounces to the pound. We can reſtore to it its original form by diſſolving it in water, and cauſing it to cryſtalliſe anew. But if after it has been calcined, we expoſe it to a continued heat, it melts on becoming red-hot into a very fuſible tranſparent greeniſh glaſs; which is ſullied by expoſure to the air, and melts in water. Even fuſion produces no change of nature on borax; we can cauſe it to reſume its original appearance, with all its peculiar properties, by ſolution and cryſtalliſation.

Air effects no alteration on this ſalt: it makes it effloreſce indeed at the ſurface by depriving it of part of the water of its cryſtalliſation. But this effloreſcence does not take place in the ſame manner on all the ſeveral kinds of purified borax of ſoda. The borax of China gives a much ſlighter effloreſcence than Dutch borax. Dutch borax likewiſe gives a more copious effloreſcence than the borax purified in Paris. This ſlight difference depends no doubt on the different proceſſes adopted for purifying it; on the manner in which its cryſtals contain water, according as they have been more ſlowly or quickly; and perhaps too on the different proportions of ſoda, and the boracic acid, which enter into its compoſition.

Borax of ſoda diſſolves very readily in water: twelve parts of cold water are neceſſary to diſſolve one of this ſalt; half that quantity of boiling water will produce the ſame effect. It is obtained in cryſtals by cooling the ſolution; but the moſt beautiful and regular cryſtals are formed in the mother-water, when it is left to evaporate ſlowly, with the ordinary temperature of the atmoſphere.

Borax of ſoda ſerves for a flux to ſiliceous earth, and joins with it to form a very fine glaſs. It is uſed in the preparation of artificial precious ſtones.

It likewiſe cauſes clay to vitrify, but with much more difficulty, and more imperfectly. This is the reaſon of its ſticking to the crucibles in which it is put to melt.

We are rather unacquainted with the action of pure barytes and magneſia on borax of ſoda. Bergman, however, ranks thoſe two ſubſtances before the alkalis in the tenth column of his table of affinities; which ſhows that he thinks them capable of decompoſing this ſalt: But in his diſſertation, he ſays, that the affinities of ponderous earth and magneſia with the boracic acid are not yet exactly known.

Lime has actually a greater affinity than ſoda with this acid. Lime-water precipitates a ſolution of this ſalt; but to make it decompoſe it entirely, we muſt boil quicklime and borax of ſoda together: an almoſt inſoluble ſaline combination of lime with the boracic acid is then depoſited, and the cauſtic ſoda is left in ſolution in the water.

Potaſh appears to decompoſe borax of ſoda as well as all other neutral ſalts with a baſe of mineral alkali. Ammoniac produces no ſort of alteration on this ſalt.

The acids act on borax in a very diſtinct manner. If into a boiling ſolution of borax of ſoda you pour a quantity of concentrated ſulphuric acid, taking care to give the liquor a very ſmall exceſs of the acid, you may obtain from this mixture, by filtrating and cooling it, a very copious precipitate in ſmall bright ſcales. This precipitate is boracic acid, and by waſhing it in diſtilled water, and drying it in the air, it is rendered very pure. By evaporating the ſolution thus prepared and leaving it to cool, we obtain from time to time new quantities of boracic acid. At laſt, the product is ſulphate of ſoda, formed by the union of the ſulphuric acid made uſe of on the occaſion, with the alkaline baſe of borax.

The nitric and the muriatic acids decompoſe borax of ſoda in the ſame manner, becauſe they, as well as the ſulphuric acid, have more affinity with ſoda than the boracic acid has. The laſt evaporations of theſe mixtures afford nitrate or muriate of ſoda. The diſcovery of the boracic acid ſeems to belong to Beccher, but has been uſually aſcribed to Homberg, he having in the Memoirs of the Academy for the year 1702, given the firſt accurate deſcription of a proceſs for obtaining it. That chemiſt obſerved this ſalt to be ſublimated in the diſtillation of a mixture of ſulphate of calcined iron with borax of ſoda and water. Imagining the firſt of theſe matters to contribute greatly to its formation, he gave it the name of *narcotic volatile ſalt of vitriol.* Lewis Lemery, eldeſt ſon to the famous Nicholas Lemery, made many experiments on borax of ſoda, and diſcovered in the year 1728, that the boracic acid, then called *ſedative ſalt*, might be obtained from it by means of pure ſulphuric acid, and that the muriatic and the nitric acids likewiſe ſeparated it; but ſublimation was the proceſs which he always uſed. We are indebted to Geoffrey the younger for the firſt complete analyſis of borax. In the year 1732, he proved that the boracic acid might be obtained by evaporation and cryſtallization; and by examining the reſidue which remained after theſe operations, found ſoda to be one of the principles of borax.

Baron's experiments on this ſalt, which were laid before the Academy in the years 1745 and 1748, added two important facts to theſe diſcoveries: The firſt, that vegetable as well as mineral acids decompoſed borax of ſoda: The ſecond, that genuine borax may be formed by uniting the boracic acid with ſoda. The laſt of theſe facts proves that the acid is entirely formed in the ſalt, and that its formation is in no degree owing to the acids employed to decompoſe the ſalt.

The fluoric, and even the carbonic acid though one of the weakeſt, appears to be capable of decompoſing borate of ſoda, and ſeparating the boracic acid. This laſt acid unites readily with the borax of commerce; its alkaline baſe requiring, to be fully ſaturated, rather more of the boracic acid than a quantity equal to the whole weight of the borax. Bergman is even of opinion that this ſalt is not fully ſaturated nor properly neutral, and that alkaline properties ſtill continue to predominate in it, till ſuch time as it receives this additional quantity of boracic acid. The properties of this neutral ſalt, when thus ſaturated, have not as yet been particularly examined.

None of the alkaline neutral ſalts, whether ſulphuric, nitric, or muriatic, acts in any manner on borax of ſoda.

This ſalt acquires a reddiſh colour when melted with combuſtible matters, ſuch as charcoal; but we know not yet what alteration it ſuffers from theſe matters.

Borax is of great utility in many of the arts. In glaſsmaking, and the aſſaying of metals, it is uſed as an excellent flux. It is uſed in ſoldering metals to make the mixture run, which is deſigned for the ſolder; and it at the ſame time ſoftens the ſurfaces of the metals to be united, and defends them from being calcined by the action of the air. It was formerly much uſed in medicine, but has gone quite out of uſe.

Species VIII. *Borate of Potaſh.*

We give the name of *borate of potaſh* to the combination of the boracic acid with potaſh. It is well known that theſe two ſaline ſubſtances readily unite, and that from their union reſults a neutral ſalt, reſembling borax of ſoda. Of this kind is the reſidue of nitre of potaſh, decompoſed by the boracic acid. M. Baumé ſays, that this reſidue appears in the form of a white half-melted glaſs, which when diſſolved in water, affords ſmall cryſtals. Borate of potaſh is therefore fuſible, ſoluble, and ſuſceptible of cryſtallization, and pure acids decompoſe it as well as borate of ſoda. We know nothing more certain of this ſalt; it ſhould be examined in the ſame manner as borate of ſoda. Baron knew the poſſibility of producing this ſalt by a direct combination of the boracic acid with potaſh; he has even diſtinguiſhed it accurately from common borax, or borax with a baſe of ſoda; but not a word has he ſaid concerning the peculiar properties of borax of potaſh.

Species IX. *Fluate of Soda.*

According to the ſyſtem of nomenclature to which we have conformed from the beginning of this work hitherto, the name *fluate of ſoda* denotes the combination of the fluoric acid with potaſh. This neutral ſalt has, as yet, undergone but a very ſlight examination—by Meſſrs Scheele and Boullanger. According to theſe two chemiſts, it always appears in a gelatinous form, and is never cryſtallized. According to Scheele, it becomes, when dried and melted, acrid, cauſtic, and gelatinous. He compares it in that ſtate to liquor of flints. It appears that fire diſengages the fluoric acid; and that the ſiliceous earth with which it is always impregnated during its preparation, then melts into a ſoluble glaſs with the help of the potaſh.

Fluate of potaſh diſſolves very readily in water. It always retains ſo large a proportion of this fluid, that it is impoſſible to make it aſſume a cryſtalline form. When it is well ſaturated, a ſolution of it produces no alteration on ſyrup of violets.

We know not in what manner either ſiliceous, argillaceous, or barytic earth or magneſia, affects this ſalt.

According to Scheele and Bergman, lime has more affinity than potaſh with the fluoric acid. Throw fluate of potaſh into lime-water it is inſtantly decompoſed: lime unites with the fluoric acid, forming an inſoluble ſalt, which takes away the purity of the liquor, and is fluate of lime. We ſhall afterwards ſee that lime likewiſe decompoſes neutral ſalts formed of the carbonic acid with fixed alkalis. We have already ſeen that lime-water precipitates borax of ſoda; therefore the fluoric is not the only acid which has a greater affinity with that ſalino-terrene ſubſtance than with the fixed alkalis.

The concentrated ſulphuric acid decompoſes fluate of potaſh by diſengaging its acid; which, according to M. Boullanger, appears in the white vaporous form, and exhales the odour peculiar to the muriatic acid. When this experiment is made in an apparatus proper for diſtillation, we obtain the fluoric aeid, juſt as we obtain the acids contained in nitre of potaſh and muriate of ſoda, when we decompoſe them with the ſulphuric acid.

No inquiry has hitherto been made concerning the action of the nitric and the muriatic acids, or of the known neutral ſalts, on fluate of potaſh. This ſalt is in other reſpects little known, and is applied to no uſe.

Species X. *Fluate of Soda.*

This is a proper enough denomination for the neutral ſalt formed by the ſaturated combination of the fluoric acid with ſoda. This, like the foregoing ſalt, has been but very little examined. No body but Meſſrs

Scheele and Boullanger, has ſaid any thing about it; and they differ in their opinions, as we are about to ſee.

Scheele aſſerts, that a combination of ſoda with the fluoric acid forms a jelly like the preceding ſalt. Boullanger, on the contrary, ſays, that the combination affords very ſmall, hard, brittle cryſtals, of an oblong ſquare figure, a bitter taſte, and ſomewhat ſtyptic. This ſalt decrepitates on burning coals like muriate of ſoda; it diſſolves in water, but not readily.

Lime-water decompoſes this ſalt as well as fluate of potaſh. The ſulphuric diſengages the fluoric acid from this ſalt with effervеſcence, cauſing it to riſe, like the muriatic acid, in a white vapour of a pungent ſmell.

From this ſhort account of this ſalt, the reader may perceive that it is not better known than the laſt.

Species XI. *Carbonate of Potaſh.*

The laſt two neutral ſalts which we have to examine, are combinations of the carbonic acid with fixed alkalis.

Theſe ſubſtances were never before reckoned among the neutral ſalts: but we ſhall immediately ſee that they are true neutral ſalts.

What we call *carbonate of Potaſh*, is a neutral ſalt reſulting from a ſaturated combination of carbonic acid with potaſh. Some modern chemiſts call it *mephitic tartar*, aërated *vegetable alkali*, &c. This ſaline ſubſtance was always taken for pure alkali, till Dr Black's experiments ſhowed it to be a neutral ſalt. Its old name was *fixed ſalt of tartar*, becauſe it was obtained by the incineration of tartar of wine. It was conſidered as an alkali, becauſe it poſſeſſes ſome of the properties of alkaline ſalts. It does indeed convert ſyrup of violets to a green colour; but borax and ſeveral other neutral ſalts poſſeſs the ſame property: beſides, it neither deſtroys nor weakens the colour of violets like potaſh. It has an alkaline taſte; but the ſame is diſtinguiſhable in borax: only it was diſtinguiſhed from alkali of ſoda by its power of attracting the moiſture of the air with great rapidity, and its not being ſuſceptible of cryſtallization. When thus moiſtened in the air, it received the name of *oil of tartar per deliquium*[*]. But fixed ſalt of tartar poſſeſſes theſe two properties only becauſe it is not a perfect neutral ſalt. Containing ſtill a certain quantity of potaſh not ſaturated with carbonic acid, this exceſs of alkali renders it deliqueſcent. At preſent, this ſalt is obtained in a ſtate in which it is very ſuſceptible of cryſtallization, and attracts no moiſture, but rather effloreſces. The Duke de Chaulnes, who has paid much attention to this object, prepares this ſalt by expoſing a ſolution of potaſh, either cauſtic or containing a little of the carbonic acid, in a place full of carbonic acid, as in the upper part of a barrel of beer when it is fermenting. The alkali ſeizes as much of the carbonic acid as it can abſorb, and is regularly cryſtalliſed. Its cryſtals are quadrangular priſms, terminating in very ſhort pyramids with four faces.

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[*] Bohnius relates, that evaporating oil of tartar ſlowly, by a moderate heat, he obtained, under a ſaline pellicle, beautiful cryſtals, which, though expoſed to various temperatures, remained ſix years unaltered (*Diſſert. Phyſico-Chem*, 1666.) M. Montet, a celebrated chemiſt of Montpelier, who was certainly unacquainted with Bohnius's diſcovery, has invented a proceſs for cryſtalliſing this fixed ſalt of tartar.—F.

Carbonate of potaſh has an urinous taſte, but much weaker than that of the cauſtic vegetable alkali; for in medicine it is given as a diſcuſſive in doſes of ſeveral grains. This neutral ſalt is very ſubject to alteration from fire; it melts eaſily, and is pretty quickly reduced to an alkali. If it be diſtilled in a retort with a receiver, and a pneumato-chemical apparatus with mercury fitted to it, the products obtained are, the water of its cryſtallization, and its acid in an aëriform ſtate. The potaſh, after this operation, remains in an irregular maſs, ſtill retaining, however, a ſmall portion of the acid, which cannot without the greateſt difficulty be extracted from it by fire. According to Bergman's analyſis of it, carbonate of potaſh, when ſaturated with the acid, and regularly cryſtalliſed, to which he gives the name of *aërated vegetable alkali*, contains in the quintal twenty parts of the acid, forty-eight of pure alkali, and thirty-two of water. But it is to be obſerved, that carbonates are more liable than other neutral ſalts to vary in the quantity of the acid. Yet, as this ſalt never furniſhes regular cryſtals but when it is fully ſaturated, Bergman's calculation deſerves to be conſidered as ſufficiently accurate.

Carbonate of potaſh, when fully cryſtalliſed, ſuffers no alteration from air; its cryſtals neither deliquiate nor effloreſce, but remain tranſparent. This ſalt, when ſo pure as to poſſeſs this property, being of uſe in many experiments, it may be proper to let the reader know that it is prepared in the following manner: By expoſing a lixivium of common potaſh, very pure and white, and ſeparated from the ſulphate of potaſh which it uſually contains, in a ſhallow diſh, in the upper part of a beer barrel; and the proceſs is the ſooner completed, if the potaſh be continually ſtirred or poured out of one veſſel into another; and if it be thus kept in contact with the carbonic acid produced by fermentation, till ſuch time as it depoſite beautiful cryſtals of carbonate of potaſh.

This ſalt diſſolves readily in four parts of cold water, and a rather ſmaller quantity of warm water will maintain it in ſolution; it produces cold as it unites with that fluid. This property which diſtinguiſhes neutral from ſimple ſalts ſufficiently determines the difference between carbonate of potaſh and pure or cauſtic potaſh. It is cryſtalliſed by evaporation and cooling conjunctly. When the ſolution is too much concentrated, it takes the form of an irregular maſs,—which often happens in the laboratories.

This ſalt, as well as potaſh, ſerves as a flux to vitrifiable earths; becauſe fire reduces it to an alkali by expelling the carbonic acid. Beſides, when this ſalt, with a mixture of ſand, is violently heated in a crucible, a lively efferveſcence may be obſerved at the inſtant of vitrification; and that efferveſcence is owing to the diſengagement of the carbonic acid. This fact ſhows that ſiliceous earth cannot enter into combination with an alkali ſaturated with this acid, and that the acid eſcapes when the vitreous combination takes place. This efferveſcence attends ſo invariably the combination of theſe two ſubſtances, that Bergman propoſes to try ſiliceous earth by means of the blow-pipe, with carbonate of potaſh, as no other earth exhibits the ſame phenomenon when heated with this ſalt.

Clay does not act at all on carbonate of potaſh; but the ſalt reduces that earth to a vitreous frit, though not quite ſo eaſily as does cauſtic potaſh. Barytes deprives this ſalt of the carbonic acid.

Lime likewiſe decompoſes it, having a greater affinity than potaſh with the acid. Lime-water poured into a ſolution of carbonate of potaſh, gives a precipitate of an almoſt inſoluble ſalt, produced by the combination of lime with the carbonic acid; and the pure or cauſtic alkali remains diſſolved in the water. In pharmacy, this proceſs is made uſe of for the preparation of the *lapis cauſticus*, which is nothing but fixed vegetable alkali rendered cauſtic by lime. Modern diſcoveries have ſhown, that Lemery's proceſs for preparing the *lapis cauſticus*, though followed by many pharmacopœiæ, is very defective. It conſiſts in mixing two pounds of aſhes obtained by the combuſtion of the huſks of grapes with lees of wine *, with a pound of quicklime, immerſing the mixture into ſixteen pounds of water, filtering it, evaporating this lixivium in a copper veſſel, melting the reſidue in a crucible, and pouring it out upon a plain ſurface. The product obtained by this operation is merely a dirty alkali not very cauſtic, and containing copper.

Bucquet, ſenſible of the diſadvantages of this proceſs,

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* These aſhes contain a great deal of vegetable alkali or carbonate and ſulphate of potaſh.

ceſs, has given one, more tedious and expenſive indeed, but much more certain and advantageous, eſpecially for preparing very pure potaſh, which is ſo neceſſary in chemical experiments. Take two pounds of very ſtrong quicklime; pour a little water upon it to reduce it to powder; add a pound of fixed ſalt of tartar, and pour upon it as much water as may be ſufficient to form it into a paſte: When this mixture becomes cool, add to it water to the quantity of ſixteen pints, and put the whole into a linen cloth lined with paper; about twelve pints of a clear liquor will paſs through this ſtrainer, and the remained is to be waſhed with four pints of boiling water to take away all the alkali. This liquor gives no efferveſcence with acids: but the beſt teſt for trying its cauſticity is to obſerve whether it clouds lime-water; for if it contain the ſmalleſt portion of carbonic acid, it will infallibly produce that effect. But as, after this firſt proceſs, it ſtill gives a precipitate with lime-water, when very pure alkali is wanted for nice experiments, the lixivium may be treated with two additional pounds of quicklime. It then paſſes very clear through the ſtrainer, and becomes ſo cauſtic as not to alter the tranſparency of lime-water. When the alkali is evaporated by fire in the open air, that ſalt abſorbs the carbonic acid contained in the atmoſphere; therefore, to obtain it in a dry form, and very pure, we muſt evaporate the liquor in a retort. But this very tedious proceſs is not neceſſary for producing the *lapis cauſticus*; for if alkali be of ſuch ſtrength as to corrode the ſurface of the ſkin, it is ſufficient for the purpoſes of that preparation. But as dry ſolid potaſh, in a ſtate of high purity, is neceſſary in many experiments, I muſt here obſerve, that the cauſtic alkaline lixivium muſt be evaporated in cloſe veſſels, and that the fire muſt be very cautiouſly managed, becauſe the evaporation is attended with conſiderable difficulty, in regard to the denſity which the liquor aſſumes towards the end of the proceſs. The fixed alkali is very white, and does not efferveſce with acids, nor deſtroy the purity of lime-water.

Magneſia does not act on carbonate of potaſh; for the carbonic acid has a greater affinity with fixed vegetable alkali than with that ſalino-terrene ſubſtance.

The ſulphuric, the nitric, the muriatic, and the fluoric acids, decompoſe carbonate of potaſh by combining with the fixed alkali, and ſeparating the carbonic acid with efferveſcence. The acid may be collected under water or mercury. It is diſtinguiſhable by the four following characteriſtics: it is more ponderous than air; it extinguiſhes lights; reddens tincture of turnſol; and precipitates lime-water.

The boracic acid ſeems incapable of ſeparating the acid from carbonate of potaſh cold; but when hot, it effects it with great eaſe.

The neutral ſalts which we have examined, neither ſuffer any alteration from carbonate of potaſh, nor produce any ſuch effect upon it.

This ſalt abounds in nature. It is often found in vegetables, completely formed, and is conſtantly obtained by the incineration of theſe organic bodies; as we ſhall have occaſion to ſhow when we come to ſpeak of the vegetable kingdom. Burnt tartar affords it in the greateſt abundance. It is alſo prepared by the detonation of nitre of potaſh.

Carbonate of potaſh is much uſed in the arts. In medicine, it is adminiſtered as an aperient and diſcuſſive, in obſtructious of the meſentery and the urinary paſſages. It is always given in ſmall doſes, and along with ſome ſubſtance of efficacy to moderate its action.

Species XII. *Carbonate of Soda.*

This ſalt, like the foregoing, was formerly thought an alkali. It is, however, a combination of the carbonic acid with mineral alkali. This ſeems to be the ſalt which the ancients called *natrum.* It is uſually called *ſalt of ſoda,* becauſe it may be obtained pure and regularly cryſtalliſed by evaporating a lixivium of common ſoda. Marine alkali is likewiſe diſtinguiſhed from vegetable fixed alkali, by its being ſuſceptible of cryſtalliſation and efflореſcence, which is owing to its being completely ſaturated with carbonic acid in its ordinary ſtate.

Carbonate of ſoda has an alkaline taſte; it communicates a green colour to ſyrup of violets, but does not like cauſtic ſoda, finally alter its colour. Its taſte is urinous, but not burning, and much weaker than that of pure marine alkali.

This ſalt is naturally purer than carbonate of potaſh, and has been long known to be ſuſceptible of cryſtalliſation; a property which may be conſidered as forming a general diſtinction between neutral and ſimple ſalts. Its cryſtalliſed form is owing to its containing almoſt always the quantity of carbonic acid neceſſary to its ſaturation and cryſtalliſation.

This ſalt, when haſtily cryſtalliſed, exhibits rhomboidal plates, diſpoſed obliquely over one another, like tiles on the roof of a houſe. When ſlowly cryſtalliſed, it aſſumes the form of rhomboidal octohædrons, with pyramids truncated near the baſe, or ſolid decahædrons, with two acute and two obtuſe angles.

This ſalt generally melts eaſier than carbonate of potaſh; for which reaſon it is uſed in preference to it in the glaſs-houſes. It loſes moſt part of its acid by heat but ſtill retains a little. Bergman has found, by an exact analyſis, that an hundred parts of carbonate of ſoda, which he calls *aërated mineral alkali*, contain ſixteen parts of the acid, twenty of pure alkali, and ſixty-four of water:—ſo that more of the acid is requiſite to ſaturate ſoda than to ſaturate potaſh; and the cryſtals of the former retain juſt twice as much water as thoſe of the latter. It is to this extraordinary quantity of water that carbonate of ſoda owes its cryſtalliſing with ſuch facility and regularity, as well as its property of efflореſcing.

Carbonate of ſoda is more ſoluble than carbonate of potaſh. It diſſolves in two parts of cold or one of boiling water. It cryſtalliſes by cooling, but gives much more regular cryſtals by ſlow evaporation.

When this ſalt is expoſed to the air, it crumbles down very readily into duſt; for the air deprives it of the water of its cryſtalliſation: But it is not altered by this efflореſcence; for we can reſtore it to its primary form by ſolution in water.

It contributes greatly to the fuſion of vitrifiable earths, and forms with them a glaſs leſs liable to alteration than that which is in part compoſed of carbonate of potaſh, to which it is for this reaſon preferred in the glaſs-houſes. It has been obſerved, that when ſand unites with this ſalt, it expels the acid, which eſcapes with a very obſervable efferveſcence, agreeably to what we have remarked of carbonate of potaſh. It has no more influence on clay than the laſt ſalt.

Barytes, as well as quicklime and limewater, decompoſes carbonate of ſoda in the ſame manner as carbonate of potaſh, and ſeparates the pure cauſtic mineral alkali. A ſolution of this ſalt poured into limewater produces a precipitate; an effect which is never produced by cauſtic ſoda. When pure cauſtic ſoda is wanted for nice chemical experiments, recourſe muſt be had to the ſame proceſs which we deſcribed above for preparing the *lapis cauſticus*.

Carbonate of ſoda, as well as carbonate of potaſh, may be decompoſed by the ſulphuric, the nitric, and the muriatic acids, &c. The carbonic acid may be obtained from it by collecting it into a glaſs filled with water or mercury.

In Egypt, this ſalt is found entirely formed at the ſurface of the earth, as well as in ſeveral other places. It is likewiſe found in the aſhes of ſea-weeds, but not completely ſaturated with the acid. To render it more perfectly neutral, it muſt be directly combined with the cretaceous acid, either by ſhaking it over ſome liquor in a ſtate of fermentation, or by receiving into a ſolution of it a portion of the carbonic acid, ſeparated from chalk by the ſulphuric acid. It may be alſo produced by wetting the ſides of a veſſel with a ſolution of ſoda, and then pouring into the veſſel a quantity of carbonic acid: the mouth of this veſſel is then to be covered with a wet bladder; and at the end of a few hours, the combination is found to be effected,—for the bladder is emptied by the abſorption of the carbonic acid, and the ſides of the veſſel are covered with the ſalt in regular cryſtals.

Carbonate of ſoda may be applied to the ſame purpoſes with carbonate of potaſh. It is much more uſed in ſoap and glaſs manufactories, &c. &c. We ſhould therefore endeavour to procure it in greater quantities, and to extract it in the great way from muriate of ſoda. We have ſeen that litharge, which ſome chemiſts pretend to be adequate to this effect, does not properly decompoſe that ſalt. We have alſo taken notice of Scheele's having diſcovered a more entire decompoſition of muriate of ſoda, effected by quicklime and iron, with the help of atmoſpheric air, and the carbonic acid which it contains. We ſee that a greater proportion of this acid than what uſually exiſts in the atmoſphere, is requiſite to promote this decompoſition, by exerting its attractive force on the ſoda.

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